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AIRCRAFT AGE IMPACT ON INDIVIDUAL OPERATING AND SUPPORT COST ELEMENTS

This study develops methodology, techniques and procedures for evaluation of age related cost trends associated with major categories of Operating and Support cost. Data sources including Naval Aviation Logistics Data Analysis (NALDA) history, Chief of Naval Operations Flying Hour Projection System Budget Analysis Reports, Visibility and Management of Operating and Support Cost Maintenance Subsystem and Total Support System reports, and Naval Depot Production Performance Reports (PPRs) were used to evaluate cost trends over the most recent ten years of cost data. Detailed data was collected on ten major Type Model Series aircraft including the P-3C, S-3A, F/A-18A/B, F-14A, CH-53E, SH-60B, E-2C, SH-3H, CH-46E and A-6E. Evaluations of age related trends and recommendations for changes in current estimating processes when appropriate have been developed for the following cost categories:

1. O&I Level Consumables/Repair Parts
2. AVDLRs
3. *Aircraft Overhaul/Support*
4. Engine Overhaul/Support
5. Petroleum, Oil, Lubricants (POL)
6. "O" and "I" level labor requirements

Results of this study clearly demonstrate age related trends of increasing costs linked to aircraft service life "fleet age" for most of the categories under examination.

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Technical Report

AIRCRAFT AGE IMPACT ON INDIVIDUAL OPERATING AND SUPPORT COST ELEMENTS

Prepared for the

27th Annual DoD Cost Analysis Symposium
Operations and Support Costing Workshop

by

NAVAL AVIATION MAINTENANCE OFFICE
LOGISTICS ENGINEERING DEPARTMENT
RESOURCE ANALYSIS DIVISION

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July 1993

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INTRODUCTION

Background: Under the current defense environment, decreasing economic resources limit new aircraft acquisition programs. As a consequence the Services are being forced to operate aging aircraft without replacement for many critical missions. The impact of this average age increase upon future operating and support costs must be assessed properly if Department of Defense decision makers are to make properly informed downsizing decisions. Most current cost studies assume essentially constant operating costs over the life of an aircraft program. Little effort is made to analyze different aging characteristics of various T/M/S. In order for the true impact of program decisions to be identified, either comparing existing platforms or assessing cost effectiveness of replacement aircraft programs, an understanding of impacts of aging on costs of aircraft operations must be determined.

Purpose of Study: This study develops methodology, techniques and procedures for evaluation of age related cost trends associated with major categories of Operating and Support cost. Data sources including Naval Aviation Logistics Data Analysis history, Chief of Naval Operations Flying Hour Projection System Budget Analysis Reports, Visibility and Management of Operating and Support Cost Maintenance Subsystem and Total Support System reports, and Naval Depot Production Performance Reports are used to evaluate cost trends over the most recent ten years of cost data covering ten major Type Model Series (T/M/S) aircraft: the P-3C, S-3A, F/A-18A/B, F-14A, CH-53E, SH-60B, E-2C, SH-3H, CH-46E and A-6E. Evaluations of age related trends and recommendations for changes in current estimating processes as appropriate are developed for the following cost categories:

1. Organizational and Intermediate Level Consumables/Repair Parts
2. Aviation Depot Level Repairables
3. Aircraft Depot Overhaul/Support
4. Petroleum, Oil, Lubricants
5. Organizational and Intermediate Level labor requirements

Format of Report: Each chapter has been developed as a "stand-alone" study in a consistent format that sequentially covers an description of the content of the cost element, a statement of the overall hypothesis of increasing age impacting average costs of operation, a description of data sources used, an analysis of results, and specific recommendations for future estimating of the element considering the impact of age. Each chapter contains sample charts illustrating data points and associated trends. References are made to appendices containing detailed data sets and associated charts for all T/M/S. These appendices are not provided with the official formal report because of the volume of paper required, but can be made available if specifically requested.

O&I LEVEL CONSUMABLES/REPAIR PARTS

Description of Consumables/Repair Parts:

Organizational and Intermediate (O&I) Level Maintenance Consumables/Repair Parts is an element identified under Unit Level Consumption during the Operating and Support (O&S) phase of the life-cycle cost of a weapon system. Consumable Material/Repair Parts are defined in the O&S Cost Guide as the costs of material consumed in the operation, maintenance, and support of aircraft systems and associated support equipment at the unit level. Depending on the maintenance concept or organization structure, consumption at the intermediate level is also reported either at this level or in element 3.0 (Intermediate Maintenance). As defined in the cost guide "O&I Level Consumables are the small lower priced items used in the maintenance functions at the O&I Level. Generally these are consumables; rags, filters, gaskets, paper, or fluids used in the maintenance and operational process or in support of this mission."

Potential Impact of Aircraft Age on Operating and Support Cost:

Previous age studies completed by NAMO personnel using Naval Aviation Logistics Data Analysis (NALDA) data show consistent age related trends of increasing failures and maintenance man hours at both the whole aircraft level and for almost all major subsystems. The purpose of this study is to evaluate if consumables/repair parts costs exhibit similar trends. The data set used for this study includes ten different Type/Model/Series (T/M/S) aircraft.

Data Sources Used for Analysis of Age Impact on Consumable Costs:

Data sources for this study include the Visibility and Management of Operating and Support Cost-Air (VAMOSC-AIR) Total Support System (TSS) and the Maintenance Subsystem (MS) Reports, and the Chief of Naval operations flying hour projection system budget analysis report (TMS) history (OP-20 report). The top level Navy reporting systems (VAMOSC-TSS/OP-20) do not presently permit consumable costs to be broken down between O&I levels except in the VAMOSC-MS reports, which generally do not give a complete cost.

VAMOSC-TSS Reports: The VAMOSC-TSS report portrays the major categories of operating and support costs of the U.S. Navy and Marine Corps aircraft weapon systems by T/M/S for a complete fiscal year and also identifies associated quantities of aircraft and flying hours. For the VAMOSC-TSS analysis, total support supply dollars were extracted for each T/M/S for the period FY83-FY91 and input into spreadsheets. All costs were then normalized to an FY93 constant dollar base and converted to costs per flight hour using the reported total flying hours. (Appendix A, enclosure 1) Data normalized in this manner was next analyzed using Linear Regression analysis. Resulting trend lines showing the least squares best fit line for each T/M/S are displayed in graphs located in Appendix A, (enclosure 2).

OP-20 Reports: Data from the OP-20 Reports was available for FY83

to FY92. For the OP-20 analysis, total consumable (MNT) costs and total flying hours were extracted and normalized in the same manner as the VAMOSC-TSS data above. Resulting spreadsheet information and trend line charts are provided in Appendix A, (enclosure 3) and (enclosure 4) respectively.

VAMOSC-MS Reports: The VAMOSC-MS report is a "bottom-up" cost visibility system that consolidates the cost of maintenance man hours and materials for each maintenance action by Work Unit Code (WUC) in specific T/M/S aircraft. In the period FY87-FY88 an ADDENDUM was incorporated into the MS report to include indirect consumable costs along with direct consumable material cost. Data from the VAMOSC-MS Reports was available for FY83 to FY91. For the VAMOSC-MS analysis, total direct maintenance consumable costs for the O&I Level and total flying hours were extracted and normalized in the same manner as the VAMOSC-TSS and OP-20 data above. Resulting spreadsheet information and trend line charts are provided in Appendix A, (enclosure 5) and (enclosure 6) respectively.

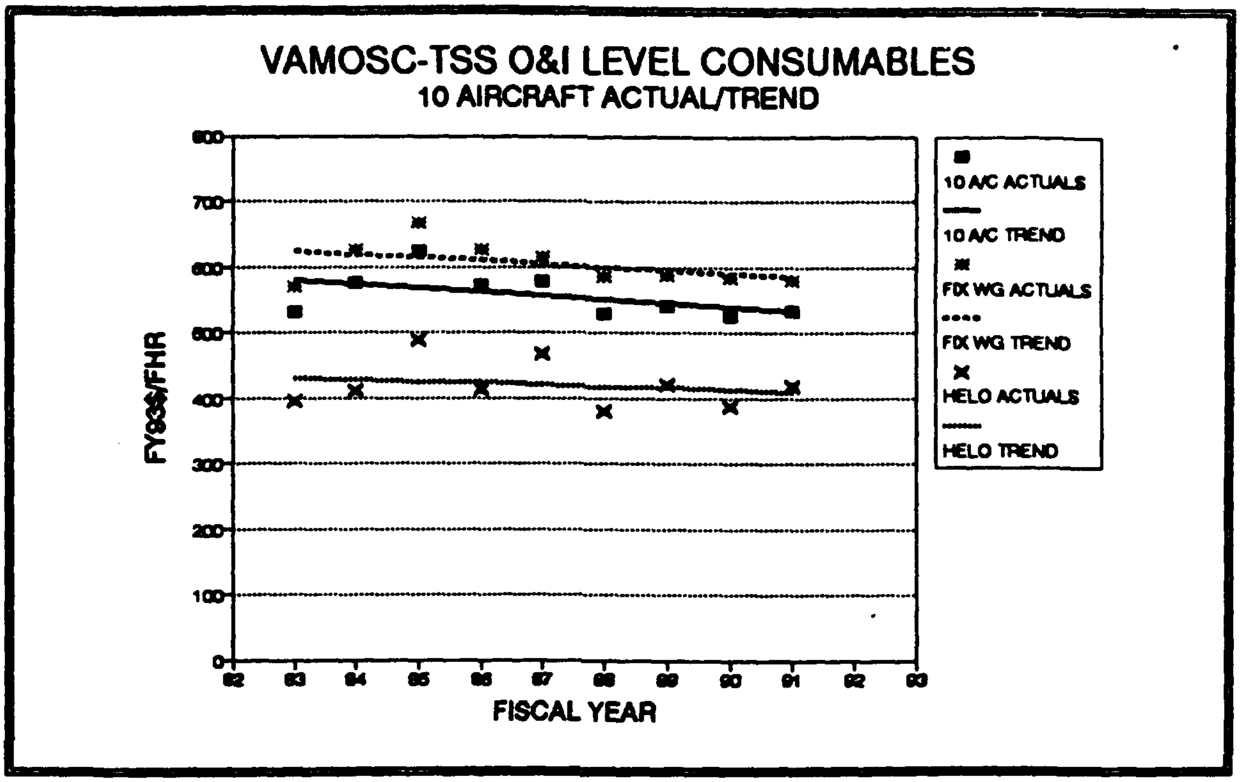
Analysis of Potential Impacts of Age on Consumable Costs:

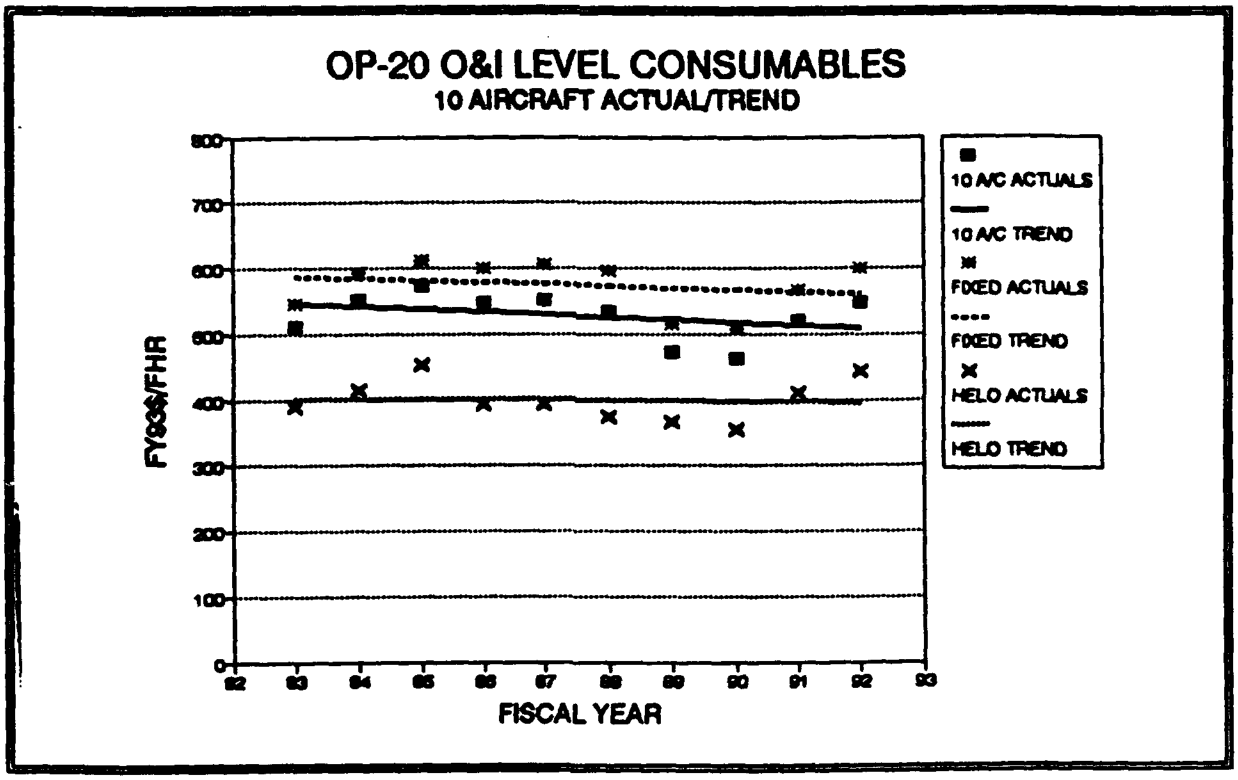
The ten T/M/S aircraft individually displayed generally consistent trends when the OP-20 and TSS data sets from FY83 through FY92 were examined. Although not all trend lines were statistically significant because of scatter of individual data points, overall results were considered to be sufficiently revealing to allow the establishment of ten year tendencies. In contrast, the MS derived trends showed substantially larger rates of increase for all but two of the T/M/S but also greater scatter of the underlying data points. The chart below summarizes the ten year trends as annual rates of change for all of the T/M/S aircraft used for the study.

T/M/S Aircraft	OP-20 Avg Change	TSS Avg Change	MS Avg Change
P-3C	0.56%	2.05%	9.91%
S-3A	1.13%	-0.42%	12.68%
CH-53E	6.28%	7.31%	21.79%
SH-60B	0.79%	-1.67%	11.20%
SH-3H	-2.51%	-0.70%	-2.17%
CH-46E	2.78%	1.24%	11.85%
E-2C	1.56%	0.61%	-1.42%
A-6E	-1.80%	-3.47%	16.75%
F-14A	-1.22%	-3.03%	3.90%
F/A-18A	0.62%	-0.16%	-1.85%
Average	0.82%	0.18%	8.26%

CONSUMABLE/REPAIR PARTS COST ANNUAL TRENDS FROM FY83-FY92

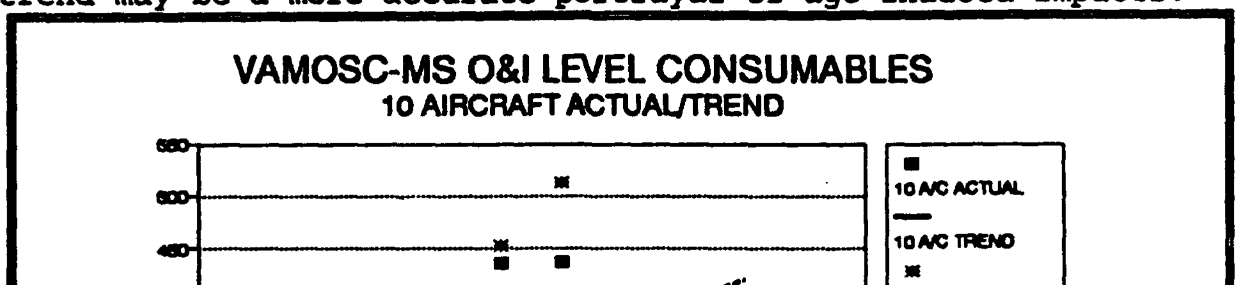
In order to more clearly identify underlying trends, the ten aircraft data sets were grouped as (1) average of all aircraft, (2) average of fixed wing aircraft and (3) average of helicopters. Resulting charts are displayed below:





After examining the above charts, it is clear that summary VAMOSC-TSS and OP-20 consumable usage trends are very similar. Further analysis and review of the graphs reveals anomalies in the data that might lead to conclusions that do not support the obvious downward trends. Each of the groups depicts an initial slight increase in consumable costs per flight hour during the period FY83-FY85 with a subsequent flattening out or decrease occurring from FY86-FY89. In FY90-FY92 a resumption of the upward trend is noted. Because of the decrease during the middle years of the data samples a significant upward trend for the period FY83-FY92 cannot be derived. However, because both VAMOSC-TSS and OP-20 reports are influenced by the availability of resources to fund the flying hour program the decrease during the period FY86-FY89 may partially represent a fleet reaction to harsh budget realities caused by declining budgets.

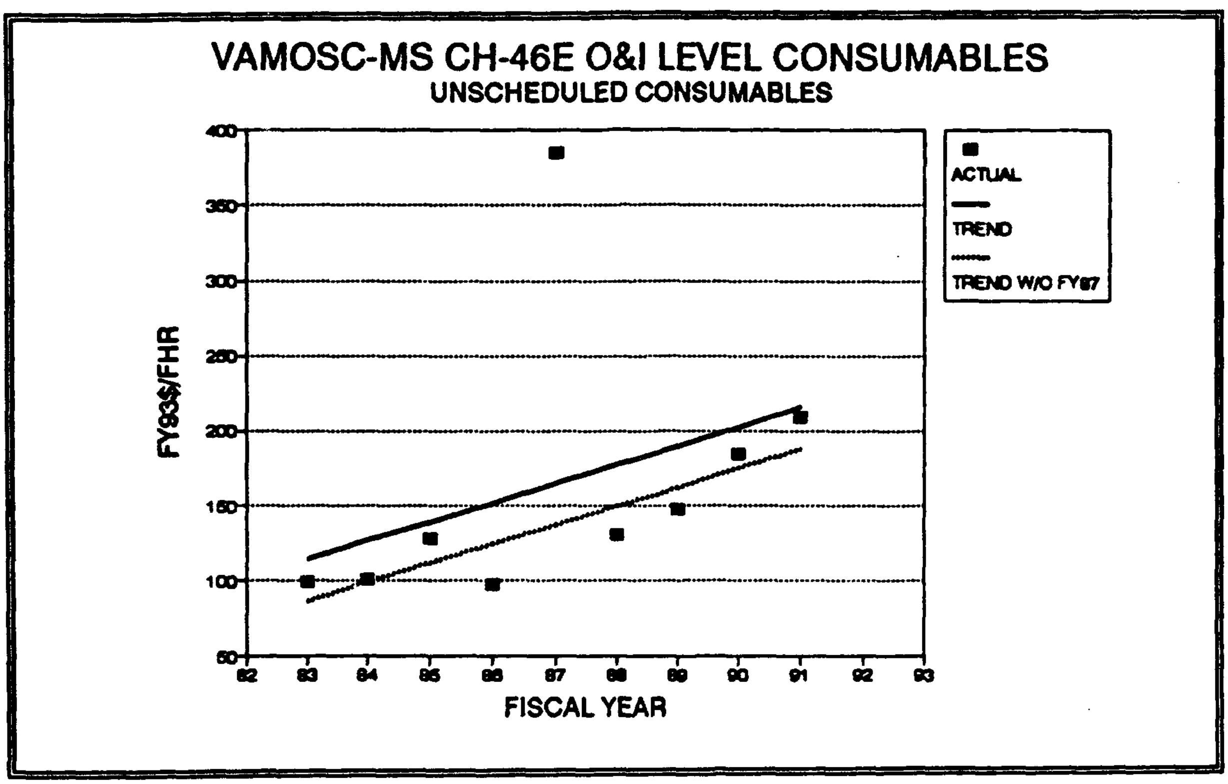
The chart for the VAMOSC-MS consumable usage per flight data set shows different tendencies. As displayed below, overall trend lines show substantially greater increases. Each of the groups show an initial decrease in consumable costs and then a large increase in FY87-FY88 followed by a slight decrease in FY89-FY91. On average the consumable costs for the period FY87-FY91 are substantially higher than the level for the first five years. Similar patterns are observed when viewing individual T/M/S aircraft data. Analysis of the data suggests that there is a definite increase in average direct consumable costs per flight hour over time even though the MS data set does not produce statistically significant results because of the wide individual variations in annual cost data points. Even though VAMOSC-MS reporting apparently does not capture all "consumable usage" because it ties costs to specific maintenance actions its overall trend may be a more accurate portrayal of age induced impacts.



Recommendations for Future Estimating of Consumable Costs:

Extensive analysis of the consumable/repair parts cost data collected **only from the OP-20 and VAMOSC-TSS data sets** does not support a recommendation for adjusting the present O&S Consumable/Repair Parts estimating methodology. When viewing the total ten T/M/S populations grouped by total, fixed wing and helicopter populations, all regression generated trends are currently declining or have flattened out. These decreasing trends are not always consistent with those observed when viewing individual T/M/S aircraft data. Some of the aircraft, in particular the CH-53E, P-3C and CH-46E, do show increasing trends. These disparities made it difficult to correlate trends for the ten individual T/M/S with the findings when the aircraft are grouped into populations.

However, when OP-20 and VAMOSC-TSS data sets are analyzed in conjunction with VAMOSC-MS data a different pattern emerges. Because the MS data does reflect actual maintenance action generated consumable usage it is considered more representative of underlying trends than the flight hour program related data. Using this data a pattern of increased usage over time is clearly supportable. Most regression generated trends using MS data do display increasing trends. As an example, the CH-46E aircraft shown below clearly demonstrates a pattern of increasing O&I Level maintenance consumable costs during the period FY83-FY91. Since no new CH-46E airframes have been purchased for many years there is a direct correlation of aircraft population age to fiscal reporting years.



The current approach for estimating maintenance consumable costs involves taking an average of the most recent three years of OP-20 and VAMOSC-TSS data. Because these data sources appear to be more inclusive of total costs this approach to estimating a base cost should be continued. However, to reflect the underlying trend of increasing costs associated with aircraft aging it is recommended that these costs be adjusted upwards by an average factor consistent with the table provided below which incorporates information from all three data sources examined for this study. The flying hour average column represents a straight average of the two "flying hour" related data sources: OP-20 and VAMOSC-TSS which contain substantially the same data. The "recommended weighted average" represents a straight average of the MS and Flying hour percentage annual change rates, and thus incorporates information taken from individual maintenance transactions that are less impacted by the budgetary process. Using both sources in this matter establishes a conservative estimating approach.

T/M/S	Flying Hr Avg	MS Average	Rec Wtd Avg
Fixed Avg	-0.30%	6.66%	3.18%
Helo Avg	1.69%	10.67%	6.18%
10 AC Avg	0.50%	8.26%	4.38%

TEN AIRCRAFT T/M/S SUMMARY TABLE
VAMOSC-MS O&I LEVEL CONSUMABLES/REPAIR PARTS

Given the variability of data from all consumable reporting systems our recommendation is that the "recommended weighted average" rates of increase be used from this table to address age related trends instead of T/M/S specific changes. Helicopters should be increased upwards by an annual increase of 6.0% while fixed wing aircraft should be increased by 3.2%. For aircraft where an overall average is considered more appropriate the average annual rate of increase is 4.3%. Our other recommendation is that changes over time in this cost category be continuously monitored to see if these percentages should be changed as additional, and possibly better data, becomes available.

END

AVIATION DEPOT LEVEL REPAIRABLES

Description of AVDLR:

Aviation Depot Level Repairables (AVDLRs) are defined as the cost of reimbursing the Navy Stock Fund (NSF) for purchases of depot-level repairable spares used to replace initial stocks. The requirement for these items originates in the squadron, and financial responsibility resides there as well with the squadron's quarterly OPTAR funding paying for required AVDLR assets. Although the squadron initiates repairable demands, the Intermediate Maintenance Activity (IMA) has primary control over whether these transactions result in an AVDLR NSF charge. When items require replacement because they are beyond capability of maintenance, lost, or have missing components a demand is made upon the supply system.

Up until 1985 AVDLR assets were paid for by appropriated funds and not directly by the fleet user of the assets. On 01 April 1985 the Navy Stock Fund capitalized over $10.0 billion in AVDLR assets (on hand and on order) and began charging users for issues. Funds were realigned in the Fiscal Year 1985 budget to the customer accounts to fund orders for purchase of AVDLRs from the stock fund. This budgetary change itself had a substantial impact upon depot level repairable requirements. To maintain consistency in the data base, this study examines trends from Fiscal Year (FY) 85 to FY92.

Potential Impact of Aircraft Age on Operating and Support Costs:

Previous age studies completed by NAMO personnel using NALDA data show consistent age related trends of increasing failures, maintenance actions and maintenance man hours per flight hour at both the whole aircraft level and for almost all major subsystems. The purpose of this study is to evaluate if AVDLR costs exhibit similar trends. The data set used for this study includes ten different Type/Model/Series (T/M/S) aircraft.

Data Sources Used for Analysis of Age Impact on AVDLR Costs:

Data sources for this study include the Total Support System (TSS) and Maintenance Subsystem (MS) of the Visibility and Management of Operating and Support Costs-AIR (VAMOSC-AIR) information system and the Chief of Naval Operations flying hour projection system budget analysis report (TMS) history (OP-20 report).

VAMOSC-TSS Reports: The TSS reports present the major categories of operating and support costs for Navy and Marine Corps aircraft weapon systems by Type/Model/Series (T/M/S) for a complete fiscal year and also provide associated quantities of aircraft and flying hours. Aviation Depot Level Repairables (AVDLR) as a separately tracked element was added to the TSS reports in FY86. For the VAMOSC-TSS analysis, total dollars normalized to a FY93 constant dollar base were extracted for each T/M/S for FY86 to FY92 and put

into spreadsheets (Appendix B, Enclosure 1). AVDLR yearly costs were converted to costs per hour using the reported operating aircraft hours. Linear Regression analysis was then employed to develop trend lines which were displayed in graphs (provided in Appendix B, Enclosure 2).

OP-20 Reports: Data from the OP-20 reports was available for FY85 to FY92. AVDLR costs and operating aircraft hours were extracted from the OP-20 reports and normalized in the same manner as the VAMOSC-TSS data above. Spreadsheet information was tabulated and trend line charts were developed (See Appendix B, Enclosure 3 and Appendix B, Enclosure 4 respectively). It must be noted that based on trends established in the subsequent years the FY85 data appears to be extremely low for all ten T/M/S. This anomaly is probably caused by the April 1985 changeover to the new accounting system and the fleet learning curve for adapting to new requisitioning and accounting procedures.

VAMOSC-MS Reports: The MS reports identify direct labor and material costs associated with scheduled and unscheduled maintenance actions occurring at the Organizational, Intermediate, and Depot levels. AVDLR was first identified in the VAMOSC-MS system in FY88. MS AVDLR costs represent annual counts of repairable items by Work Unit Code (WUC) times average WUC specific repair costs for items that were determined to be Beyond Capability of Maintenance (BCM) and returned to the depot level for repair. **MS reported AVDLR costs do not represent operational unit expenditures, but they do represent demand upon the supply system to repair items that have failed.** AVDLR costs and operating aircraft hours were extracted from the VAMOSC-MS reports and normalized in the same manner as the data sets described above. Spreadsheet information was tabulated and trend line charts were developed (See Appendix B, Enclosure 5 and Appendix B, Enclosure 6 respectively). All ten T/M/S identified **increasing costs per flight hour over the four year period.** This trend is directly related to higher failure rates exhibited by the older aircraft populations.

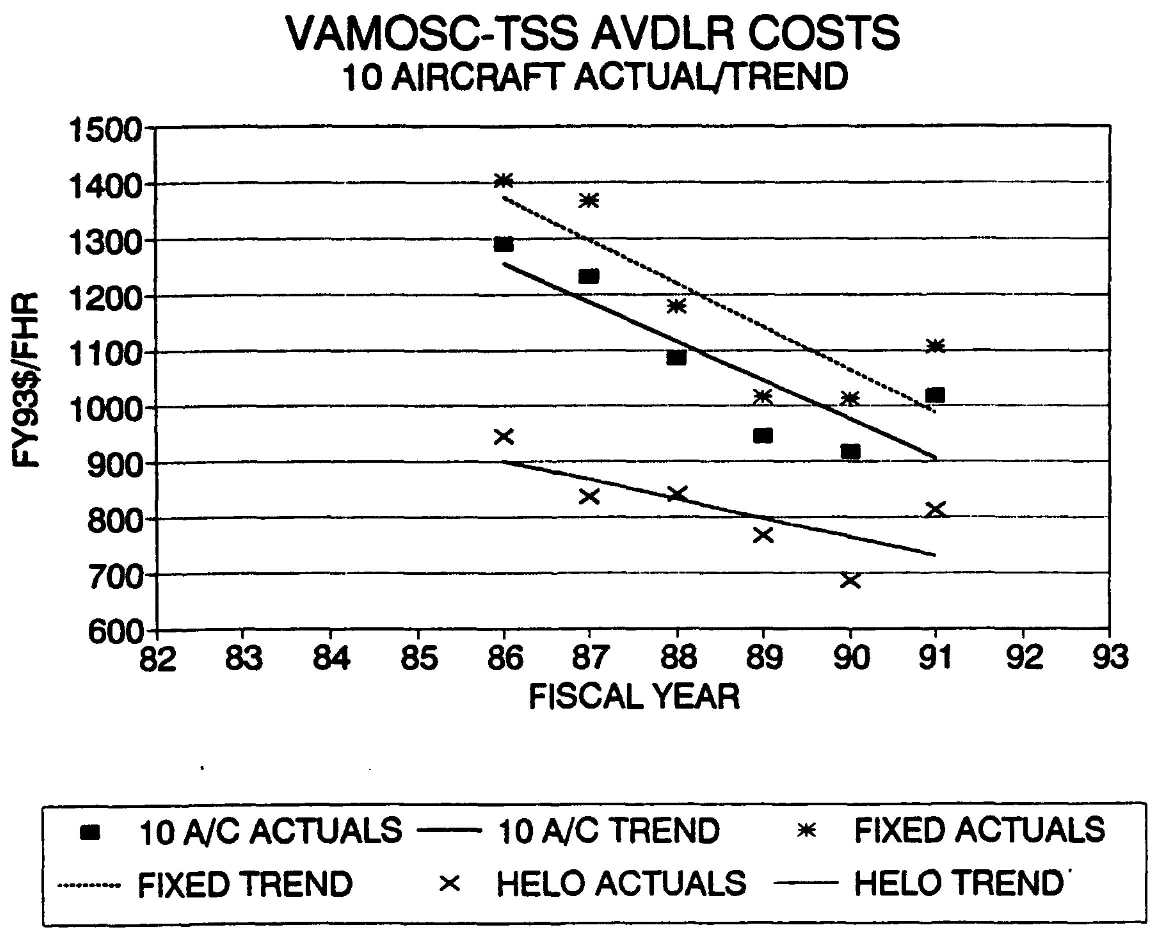
Analysis of Potential Impacts of Age on AVDLR Costs:

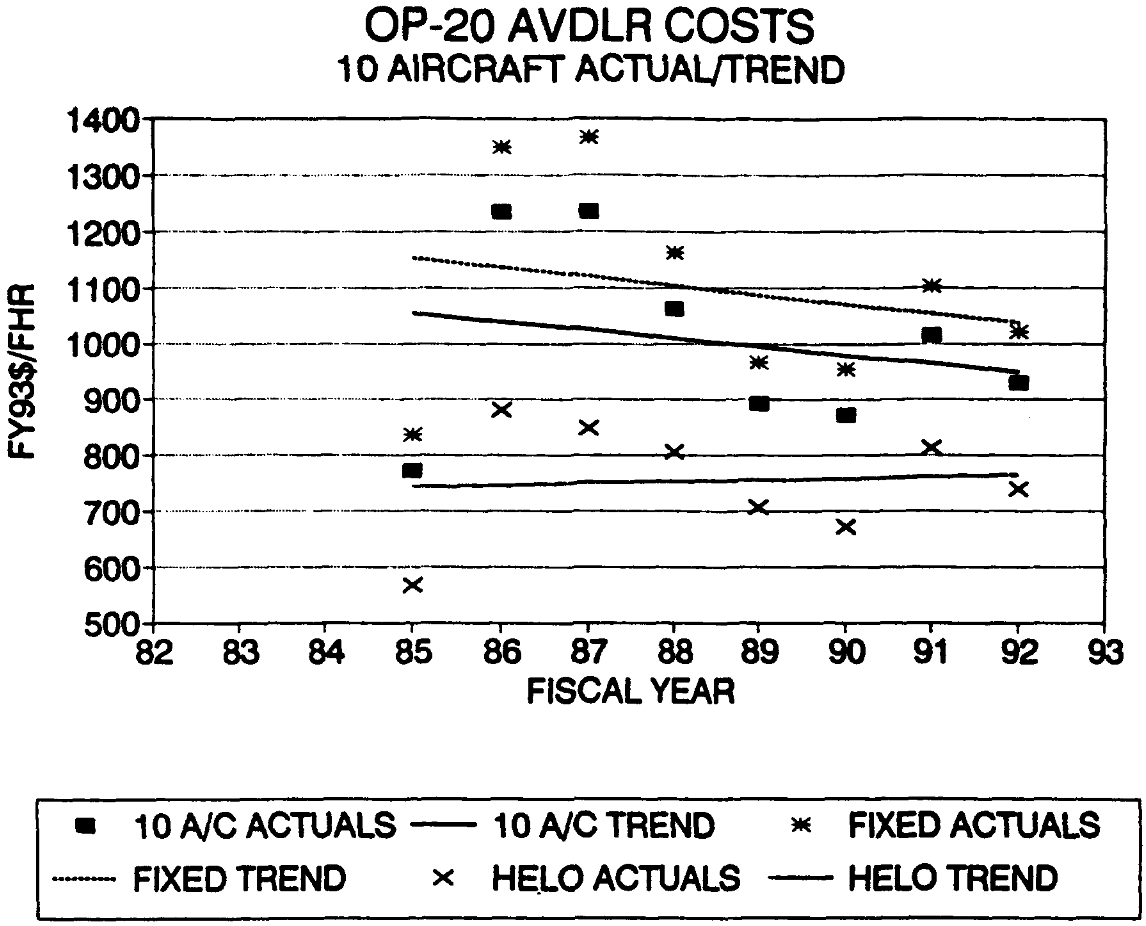
Budget Requirement Trends: The ten T/M/S aircraft individually display essentially similar trends when the VAMOSC-TSS and OP-20 data sets are compared. Both data sets represent the fleet user's actual expenditures to draw down stocks from the supply system for repairable items. Summary results identified as percentage changes by year are displayed in the "AVDLR ANNUAL BUDGETARY COST CHANGE TRENDS FROM FY85-FY92" table. It must be noted that there was significant scatter of the individual data points from which the trends lines were established, and that the trend lines from which these annual changes were derived are not all statistically significant. In addition, the consistently greater decreases in the VAMOSC-TSS column are primarily caused by the FY85 OP-20 data which is very low for all T/M/S. The AVDLR category was not identified in VAMOSC-TSS until FY86.

T/M/S Aircraft	OP-20 Annual Change	TSS Annual Change
P-3C	-0.42%	-4.24%
S-3A	-1.26%	-2.91%
CH-53E	0.37%	-8.70%
SH-60B	-5.16%	-12.28%
SH-3H	-1.31%	-6.55%
CH-46E	6.73%	-9.67%
E-2C	4.44%	0.05%
A-6E	0.07%	-4.66%
F-14A	1.16%	-3.84%
F/A-18A	-9.42%	-16.42%

AVDLR ANNUAL BUDGETARY COST CHANGE TRENDS FROM FY85-FY92

In order to better define the underlying budget requirement level trends the ten aircraft data sets were grouped as (1) average of all aircraft, (2) average of fixed wing aircraft and (3) average of helicopters. Resulting charts are displayed below:





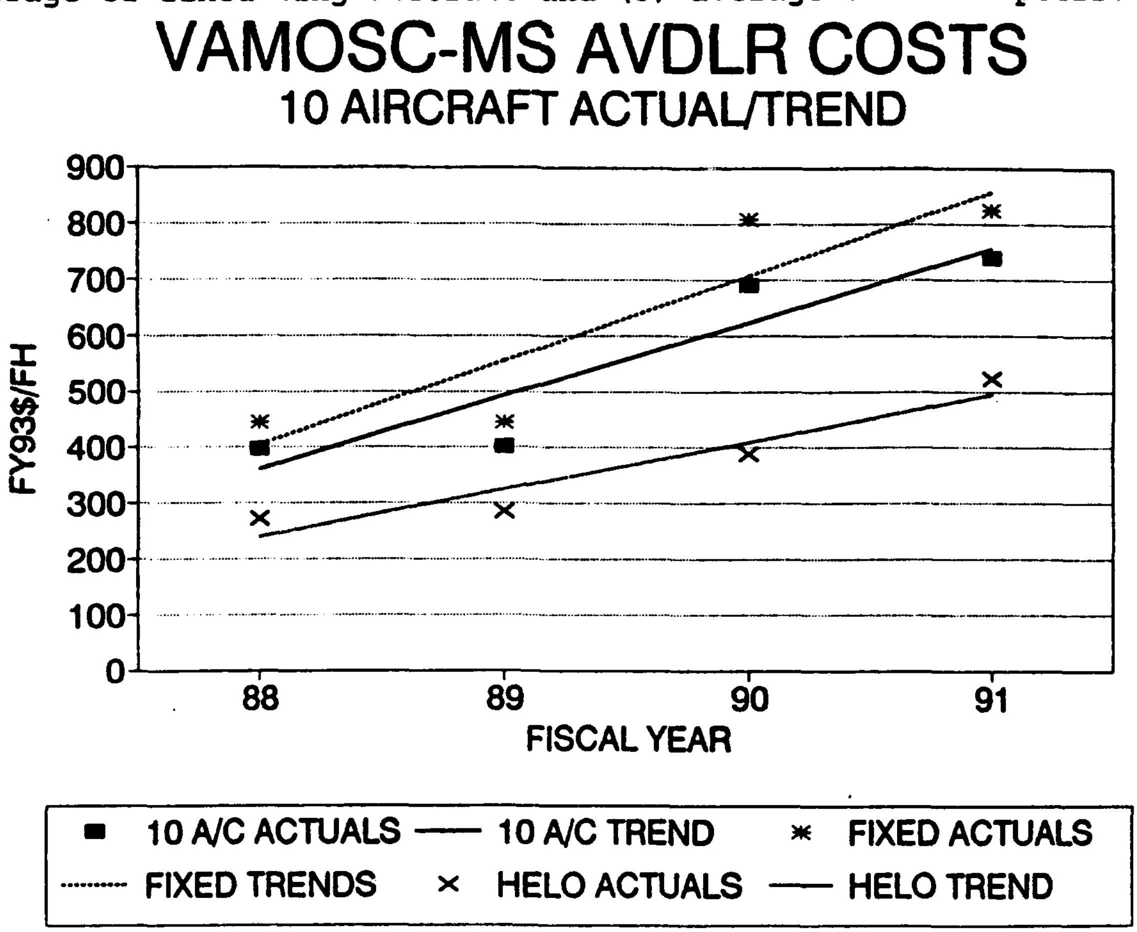
From the charts not only the scatter of the data is apparent but a basic consistency in the underlying trends. Each of the groups shows an initial steady decrease in average AVDLR costs per flying hour from FY86 to FY90. However, the FY91 and FY92 data points show a marked increase from the previous trend. Based upon inputs from fleet personnel it is possible that the initial downward trend represented the fleet's response to a budgetary stimulus more than a reflection of age impacts. When depot level repairables were no longer "free" to the fleet user, basic changes in procedures resulted. More items were fixed at the Intermediate level and much more conscientious attempts were made to turn in "failed items" because the user paid much more for a AVDLR item from stock when no "carcass" was turned in. It is possible that the upturn after FY90 represents an underlying age related increase that is taking over after the AVDLR system has reached a degree of equilibrium.

Maintenance Requirement Trends: The maintenance requirement trends portray a dramatically different perspective. Summary results identified as percentage changes by year are displayed in the "AVDLR ANNUAL MAINTENANCE REQUIREMENT TRENDS FROM FY88-FY91" table. As noted these trends are related to cost of failed repairable items returned to the depot for repair. Although there is considerable divergence of the four data points for each T/M/S the trends are all unmistakably upwards.

T/M/S Aircraft	MS Annual Change
P-3C	19.08%
S-3A	30.66%
CH-53E	39.97%
SH-60B	28.74%
SH-3H	12.82%
CH-46E	32.32%
E-2C	6.75%
A-6E	39.15%
F-14A	51.43%
F/A-18A	23.90%

AVDLR ANNUAL MAINTENANCE REQUIREMENT TRENDS FROM FY88-FY91

As on the budgetary expenditure data a chart was developed that is displayed below that portrays the AVDLR maintenance requirement driven data in the groupings of (1) average of all aircraft, (2) average of fixed wing aircraft and (3) average of helicopters.



Recommendations for Future Estimating of AVDLR Costs:

Extensive analyses of the AVDLR element leads to a qualified recommendation for making changes in the current O&S AVDLR element estimating process. Within the budget usage history VAMOSC-TSS and OP-20 data sets, covering either the total ten aircraft T/M/S population or subsets consisting of fixed wing and helicopters groupings, all results display remarkably consistent trends. Although the regression generated lines are declining, additional analysis of how the data points are distributed reveals a consistent pattern whereby the rate of decline apparently changes after FY90. Similar patterns are observed when viewing individual T/M/S aircraft data, except in the case of the CH-46E which shows consistent increases in AVDLR costs for all years. This particular aircraft is the oldest in our sample population and has very significant maintenance problems. Given the trends established in the VAMOSC-MS maintenance requirement data, which show uniform increases especially concentrated in FY90 and FY91 and a significant closure with budget usage history trends, it is likely the flying hour driven VAMOSC-TSS and OP-20 data sets will show increasing trends in the immediate future. Our recommendation is that the basic requirement be identified using a combination of OP-20 and VAMOSC-TSS data as it has been in the past for each T/M/S aircraft. This cost should then be increased by an annual percentage as displayed in the table below, RECOMMENDED WEIGHTED AVERAGE AVDLR ANNUAL CHANGE RATES, which represents two-thirds weight for the TSS percentage change (considered to be the more accurate flying hour budget driven trend) and a one-thirds weight for the MS percentage change.

Group Description	TSS-Budget	MS-Maintenance	**Wtd Average**
Fixed Wing Average	-6.40%	28.6%	**5.3%**
Rotary Wing Average	-4.10%	27.4%	**6.4%**

RECOMMENDED WEIGHTED AVERAGE AVDLR ANNUAL CHANGE RATES

The weighted average percentage increases displayed in the above table represent a current judgement as to how to adjust AVDLR requirements for the increasing incidence of failures and required maintenance actions associated with increased aircraft operational age. These rates should be re-examined annually to see if the trends appeared to be changing.

END

AIRCRAFT OVERHAUL/SUPPORT

Description of Aircraft Overhaul/Support:

Depot aircraft overhaul/support includes the costs associated with organic or commercial depot rework of Naval aircraft. Through a process identified as Standard Depot Level Maintenance (SDLM) aircraft are inducted on a recurring basis for correction of corrosion and structural problems that cannot be fixed at the organizational level of maintenance. Each inducted aircraft is given a series of conditional inspections to determine how much rework is required. Disassembly, repair, replacement of specific aircraft components, reassembly and test costs are incurred that are related to the condition of the inducted aircraft. On most major Navy T/M/S, aircraft rework efforts have historically been accomplished at the six Naval Aviation Depots (NADEPS).

Over the last ten years there have been significant changes in how aircraft rework has been accomplished. Each T/M/S has a normal "tour" length embodied in an Operating Service Period (OSP) which represents the standard cycle for return visits to the depot. In 1984 a new policy was implemented, Aircraft Service Period Adjustment (ASPA), which allowed individual aircraft to have depot rework visits deferred after successfully passing an ASPA inspection. Implementation of ASPA has led to longer average tour lengths. In addition, several significant changes have been made within the NADEPs' management structures, accounting systems and underlying budget processes. A major effort was initiated in the FY88 time frame to reduce NADEP levels of management and related overhead costs. In 1989, many types of material and component kit costs, which had previously been provided as Government Furnished Material (GFM), became a direct charge to the customer.

Potential Impact of Aircraft Age on Operating and Support Costs:

Previous age studies completed by NAMO personnel using **Naval Aviation Logistics Data Analysis** (NALDA) data show consistent age related trends of increased failures, maintenance actions and maintenance man hours per flight hour at both the whole aircraft level and for almost all major subsystems. It seems reasonable to assume that SDLM unit costs are also affected by the increasing age of the aircraft populations that undergo rework. The data set used for this study includes ten T/M/S aircraft.

Data Sources Used for Analysis of Age Impact on SDLM Costs:

Data sources used for this study include Naval Industrial Performance Summary (NIPS) reports for Naval Aviation Depot Facilities (1985-1992), NADEP Production Performance Reports (PPRs) from 1985-1992, Navy Avionics Installation Plan (1991) and Naval Aviation Logistics Data Analysis (NALDA) data sets.

Naval Industrial Performance Summary Reports: The annual NIPS reports provide completion and pricing information by depot job for all rework and modification actions by reporting depot. This data source, currently used to develop rework Operations and Support estimates, is not traceable to individual aircraft/age because bureau number references are not included. The NIPS database was initially used to establish trends by Fiscal Year and to examine overhead and labor rate fluctuations for the study aircraft.

Production Performance Reports: Performance Reports (PPR) are prepared each quarter by each individual NADEP. A complete computer data set incorporating these reports was obtained from the Naval Aviation Depot Operation Center (NADOC) covering the eight most recent years of reported costs (FY85-FY92). The PPR provides information by individual aircraft bureau number relating to induction date, days in process, completion date, hours expended and various cost reporting categories. It contains sufficient detail to examine costs per aircraft in a true chronological perspective. The same T/M/S aircraft were evaluated using this database. Except for the F/A-18A, data was extracted from sub-program code categories (36) SDLM and (38) SDLM MOD only. With the F/A-18A, data was extracted from sub-programs (54) Modification Corrosion and Paint Program (MCAPP) and (64) Age Exploration Program Development (AEPD) for comparison. Key cost fields used in this study are described below:

Direct Man-hours represents the actual direct civilian man hours incurred to rework each completed aircraft.

Direct Material Cost represents the direct costs for raw materials, components and kits incurred by the NADEPS. Since 1989 this category includes GFM that would have previously been considered a statistical cost.

Overhead Cost includes production overhead and general and administrative (G&A) expenses at the NADEPS.

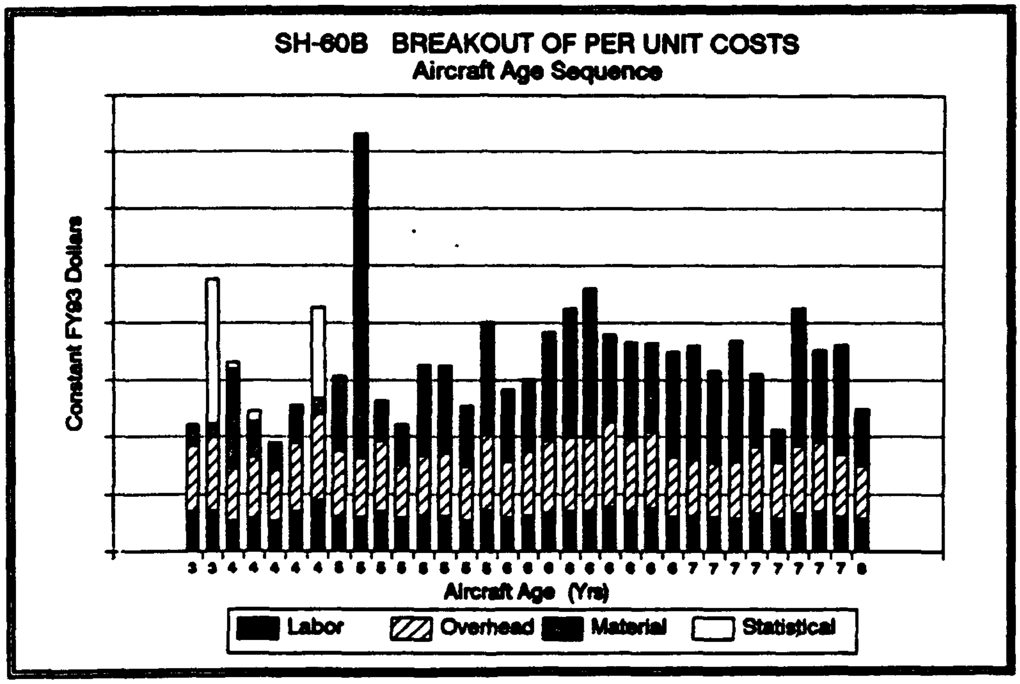
Statistical Cost represents costs associated with military labor, which is generally insignificant, and GFM. This cost element tends to fluctuate widely from 1984-1988 by individual job. In Fiscal Year 1989 it virtually disappears since all GFM was added to the Direct Material cost category.

NIF Total Cost, represents "actual cost charged" by the NADEPS including direct labor hours times cost of that effort, direct material and applied overhead.

Navy Avionics Installation Plan (1991) and Naval Aviation Logistics Data Analysis (NALDA) data: These data sets were used to establish production dates, configuration information and first year of service dates by bureau number for aircraft in the PPR data base.

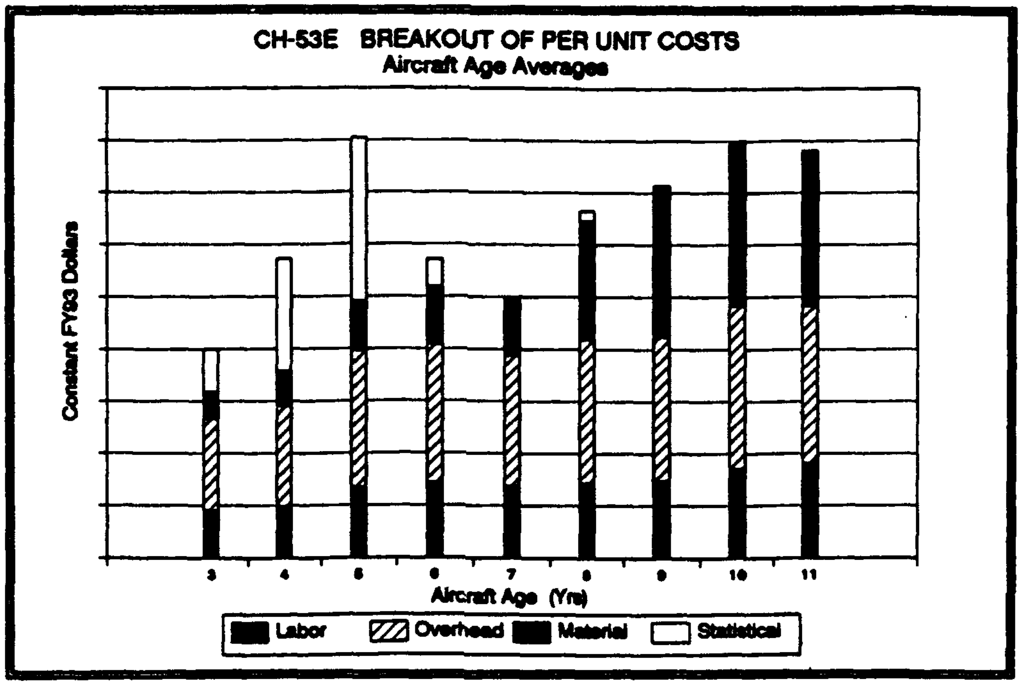
Analysis of Potential Impacts of Age on Aircraft Overhaul/Support:

The above databases were consolidated into spreadsheets for each of the study aircraft. All cost data was inflated from fiscal year actuals to MID-FY 1993 constant dollars using February 1992 NCA inflation indices [O&MN/LF (COMPOSITE)]. Aircraft age was calculated using look-up tables tied to individual aircraft bureau numbers and SDLM completion dates. After the data was normalized, each T/M/S data set was sorted from the newest to the oldest data point defined as years since entrance into the operating inventory. The four major components comprising rework cost; Direct Labor, Overhead, Direct Material and Statistical costs, were identified separately. As an example the graph below shows the SH-60B's chronological SDLM completions on a per unit basis identified in increasing service age order:



All T/M/S were similarly plotted and graphed by individual rework completion units to verify that there were age related trends for all study aircraft. Although definite underlying trends were clear, it was also obvious that individual aircraft within the same age group had tremendous differences in reported costs. This situation was particularly acute in the category of statistical costs. The problem then became how to most accurately project future age related trends given the anomalies in the underlying data.

In order to better evaluate age related trends, all aircraft completions within the same service-year age-group were averaged to obtain a single "age averaged" data point. This age grouping of data was then used as the basis for developing trend analyses. In addition, average costs per hour were identified and plotted for all aircraft in the data base to highlight any underlying changes in Depot rate structures. An example of this average age analysis, reported in Appendix C, Enclosure 1, is shown for the CH-53E below:

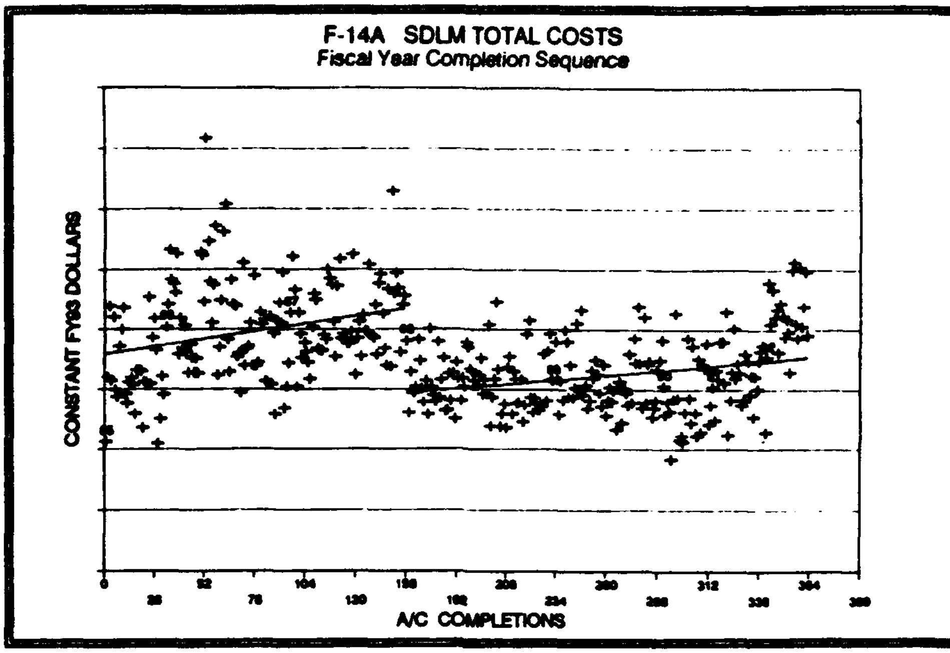


Development of Trend Lines for SDLM Age Related Impacts:

Other than inflating to constant dollars and developing average costs by service year, no manipulations of the PPR data were performed. Using regression analysis, trend lines were developed for Direct Labor, Overhead, Direct Material, Statistical and Total {unit} cost for the T/M/S under evaluation. Results are contained in Appendix C, Enclosure 2. It must be noted that there was significant scatter of the individual data points from which the trend lines were established, and that the lines from which these annual changes were derived are not all statistically significant. However, it is felt that these trends are reasonable enough indicators to develop annual average change rates by T/M/S for the period FY85 through FY92.

The table below shows the age related percentage changes for the aircraft under study for Direct Labor, Overhead, Direct Material, Statistical and Total {unit} costs. Two of the T/M/S show negative trends in unit costs relative to age and are considered exceptions. The aircraft are the F-14A and the CH-46E. With the F-14A, clearly depicted in the example below, there was a

sharp drop-off in reported costs at the beginning of the public/private depot competition in FY88. Therefore, when sequenced by age, the overall trend is obscured by accounting and related reporting changes caused by that competition.



The CH-46E went through a complete Safety, Reliability & Maintainability (SR&M) from 1985-88 where the entire airframe was reworked and refitted to the extent that later SDLM's were accomplished on essentially "newer" aircraft. (Some aircraft are on their 4th or 5th ASPA from that SR&M.)

ANNUAL COST CHANGE TRENDS ASSOCIATED WITH AIRCRAFT SERVICE YEAR

T/M/S Aircraft	Direct Labor	Over-head	Direct Matl.	Statist-ical	{Unit} Total	*Weighted Total*
A-6E	1.16	1.47	3.95	6.39	1.46	1.81
CH-46E	2.21	-0.30	0.15	-18.85	-1.64	1.05
CH-53E	7.94	6.10	36.89	-179.52	6.19	3.18
E-2C	8.41	6.21	9.38	4.36	6.99	7.94
F-14A	0.63	1.40	-2.27	-8.35	-1.69	0.28
F/A-18A	10.64	9.00	29.51	-8.05	9.96	13.92
P-3C	3.28	2.85	4.32	-1.22	2.86	3.36
S-3A	5.81	4.06	16.18	-13.27	6.50	7.37
SH-3H	2.46	2.42	15.08	-178.28	1.81	4.97
SH-60B	-1.94	-1.58	40.34	-29.11	1.60	6.62

DEPOT AIRCRAFT OVERHAUL/SUPPORT COST TRENDS

It should also be noted that the SH-60B, being the newest T/M/S to undergo SDLM, does not have sufficient years to strongly show age related impacts.

The category "NIF Total Cost" was not used in our trend analysis since the new database enabled us to extract and examine overhead separately. Statistical cost trends (due to the changes in reporting requirements) were almost all negative, and varied so widely, they were not considered usable. Direct material cost trends showed the largest increases and again are most likely due to the transfer of costs from the statistical reporting category. Although material would normally be considered a very reliable cost figure, the current trends are probably on the high side because of these changes.

Conclusions:

The current process for estimating "actual costs" associated with aircraft rework is to take an average of the most recent three years of available cost data (usually FY89-FY91) from the NIPS and develop an average cost-per-rework event. That cost is then converted into a cost-per-aircraft-year based upon the anticipated tour length. Given an upward trend in the rework costs this methodology necessarily ignores significant increases occurring from the data set average year to the current year. Our recommendation for the T/M/S reviewed in this study is that the *Weighted Total* annual trend column be used to adjust costs upwards to the desired actual year. The P-3C, for example, would need to be increased 3.36% for each year beyond the average base year. For an aircraft not in this study, it is recommended that an annual change of six percent be used. These weighted averages were developed in the following manner:

Direct labor is judged to be the least easily manipulated and therefore the most reliable cost trend figure because it represents the core effort required for assembly, disassembly and repair of each aircraft. It was weighted at *50 percent.*

Overhead, because it reflects changes in business base and accounting practices, was considered to be a less reliable, but still necessary component of any overall trend. To reflect this posture it was weighted at *30 percent.*

Direct material, because it has been impacted by changes to the statistical cost as discussed above, is in a state of change at this time. It would normally be considered second in importance, but at this time it was weighted at *20 percent.*

The six percent average annual increase recommended for T/M/S not examined for this report is based on an average of the ten PPR aircraft databases' ***Weighted Totals***.

Additional conclusions:

Increasing budget shortfalls are likely to obscure age related trends in future aircraft rework requirements. From current message traffic, it appears that aircraft with significant problems requiring substantial airframe component repair are likely to be stricken. The continuing effort to reduce depot costs through competition will add significant new variables. Trends in material costs may become more clear once the accounting perturbations caused by changes to the statistical cost category have dampened out. Despite these issues it appears clear from eight years of reasonably consistent data that increasing aircraft age does drive higher rework costs. In addition, as airframes get older, ASPA inspection deferrals are likely to be decreased with resultant shorter tours and higher annual costs trends.

END

PETROLEUM, OIL AND LUBRICANTS (POL)

Description of POL:

The petroleum, oil and lubricant (POL) Operating and Support (O&S) cost element is a subcategory of unit level consumption costs. It is defined as the cost of petroleum, oil and lubricants required for peacetime flight operations of Naval aircraft. It includes all fuel consumed both in direct flight operations of the aircraft and in maintenance related functions requiring use of on-aircraft engines and auxiliary power units. For this analysis a single data source (the OP-20 report) has been used to examine the ten most recent years of fuel usage data for the P-3C, S-3A, CH-53E, SH-60B, SH-3H, CH-46E, E-2C, A-6E, F-14A and F/A-18A aircraft. Assuming there have been no significant changes in the way POL data was collected during the study period, use of this single data source should yield internally consistent results.

This analysis evaluates potential correlation of aircraft service age with changes in POL usage per aircraft flight hour. Our working assumption is that individual aircraft service ages are strongly correlated to configuration changes that a T/M/S undergoes during its lifetime. Numerous modifications incorporated during the life of an aircraft change flying characteristics, weight distribution, total weight, and other performance factors that influence POL consumption. In addition to these types of aircraft "configuration growth" phenomena individual aircraft exhibit age induced usage characteristics such as repair patches, replaced rivets, redundant cable runs and so forth that can increase fuel consumption. To examine how these diverse forces impact POL usage over time a data base was constructed from OP-20 consumption information during the period FY83-FY92. Average annual POL usage rates expressed as gallons per flight hour were examined for each T/M/S. Resultant trends were analyzed to determine patterns of POL usage.

Potential Impact of Aircraft Age on Operating and Support Costs:

Previous age studies completed by NAMO personnel using NALDA data show consistent age related trends of increasing failures, maintenance actions and maintenance man hours per flight hour at both the whole aircraft level and for almost all major subsystems. The purpose of this study is to determine if POL usage exhibits similar trends that can be correlated with aircraft age.

Data Sources Used for Analysis of Age Impact on POL Costs:

The data source used for this study is the Chief of Naval Operations flying hour projection system budget analysis report (TMS) history (OP-20 report).

OP-20 Reports: The method currently employed to determine POL usage involves extracting annual barrels consumed and flight hour information from either the OP-20 Reports or NAVAIRNOTE C10340. Since data contained in NAVAIRNOTE C10340 is derived from the OP-20 report, the OP-20 data set only was used for this analysis. Flight hours, barrels consumed and total then year dollars expended for

POL were extracted for each T/M/S for the period FY83 to FY92 and entered into spreadsheets contained in Appendix E, Enclosure 1. The dollars were normalized to FY93 using fuel specific escalation factors from the Feb 92 NCA inflation indices. Within the spreadsheet, barrels were also converted to gallons at the rate of 42 gallons per barrel in order to compute gallons per flight hour usage rates. The gallons per flight hour and cost of fuel per flight hour data sets were then examined using regression analysis. Given the very great fluctuations in fuel costs per gallon, which the inflation factors do not completely normalize, the POL cost per flight hour trends were not considered reliable. Consequently, POL gallons consumed per flight hour data was used to establish trend lines which are displayed in the graphs contained in Appendix E, Enclosure 2. This gallons per flight hour information can readily be normalized to FY93 dollars using the current NAVPETOFF NOTICE 4265 (6 Nov 1992) rate for JP-5 of $.75 per gallon.

Analysis of Potential Impacts of Age on POL Costs:

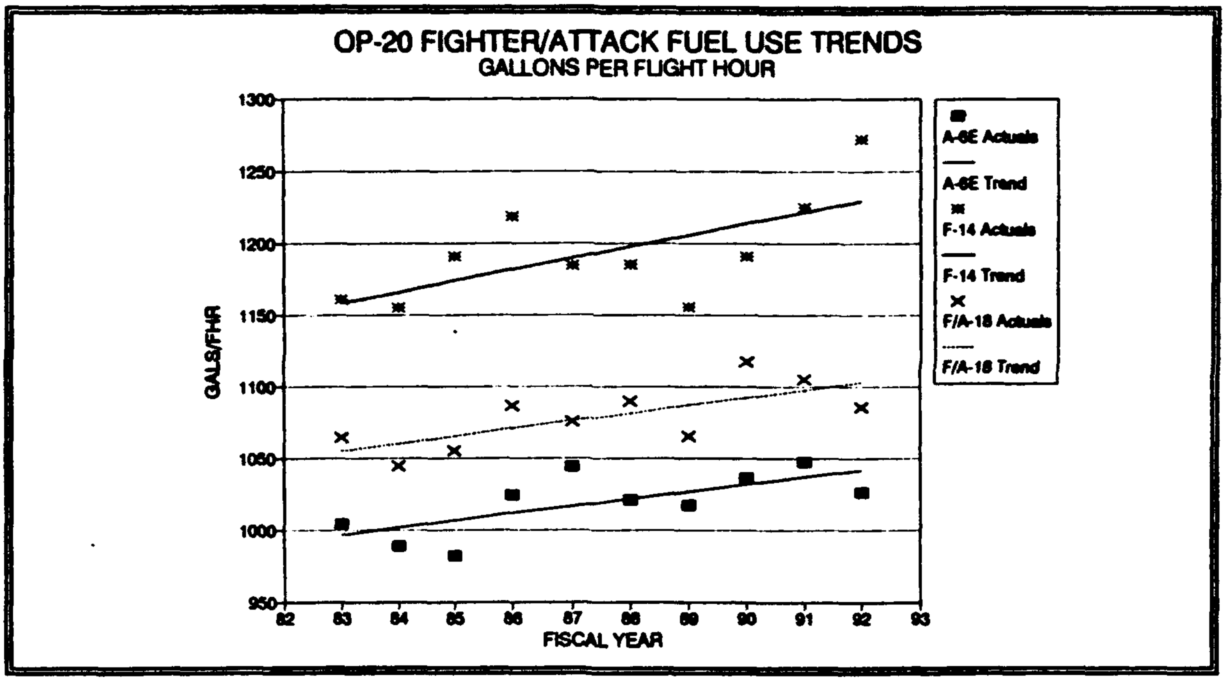
Data from the OP-20 data base was analyzed for each T/M/S aircraft for the years FY83 to FY92. For the initial summary analysis usage data representing the entire fleet was examined by T/M/S. Annual percentage changes were calculated using ten year trend lines established using regression analysis. It is important to note that the individual T/M/S trend lines are not all statistically valid at high confidence levels. There is a significant scatter of the underlying data which appears to have an embedded cyclical trend. Various exponential smoothing and non linear trends were examined for best fit to the data. After extensive analysis we have concluded that simple linear equations provide the most reasonable indication of underlying trends and that they are reliable enough indicators to develop annual average change rates by T/M/S. Summary results expressed as annual percentage changes are displayed in the table below.

T/M/S Aircraft	Fleet Annual Change
P-3C	0.36%
S-3A	1.75%
CH-53E	0.32%
SH-60B	0.80%
SH-3H	0.71%
CH-46E	-0.57%
E-2C	0.88%
A-6E	0.49%
F-14A	0.67%
F/A-18A	0.50%
10 AC Avg	0.59%

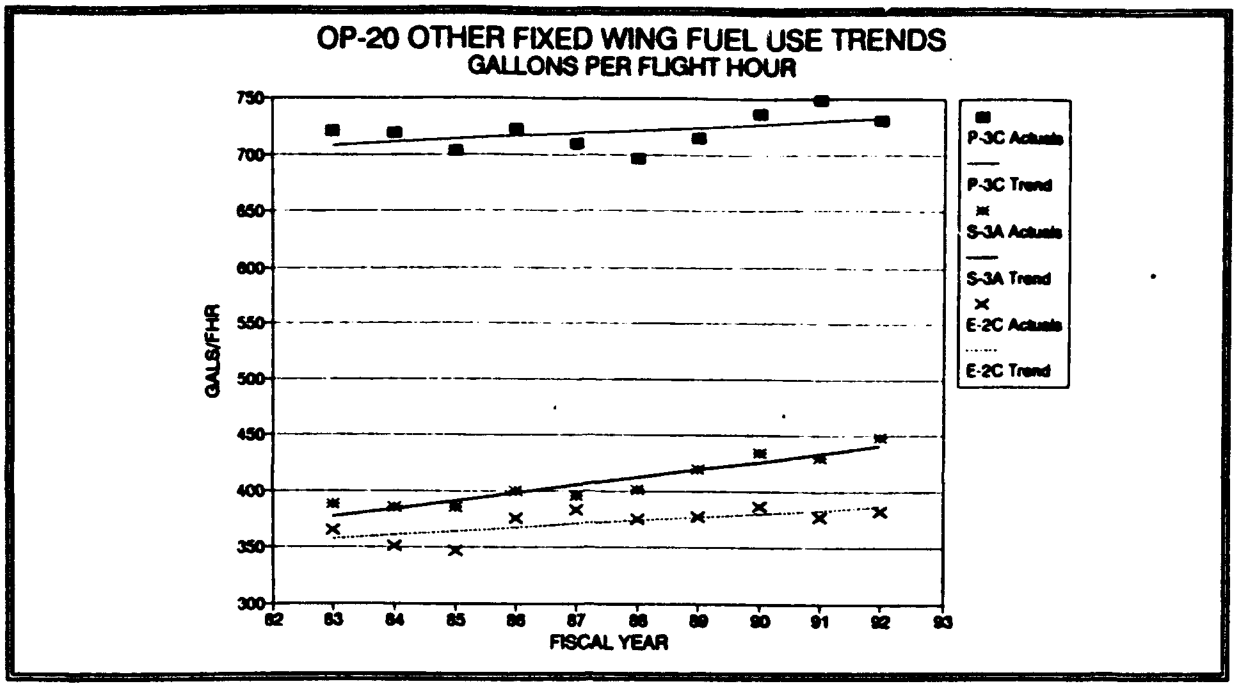
POL AVERAGE ANNUAL CHANGE RATES FROM FY83-FY92

In order to better explain and portray the trends described above four charts are provided below that group the aircraft studied into the following categories, (1) Fighter/Attack Fuel Use Trends, (2) Other Fixed Wing Fuel Use Trends, (3) Helicopter Fuel Use Trends, and (4) CH-46E Fuel Use Trends. Brief discussions are provided for each grouping based upon total fleet usage data.

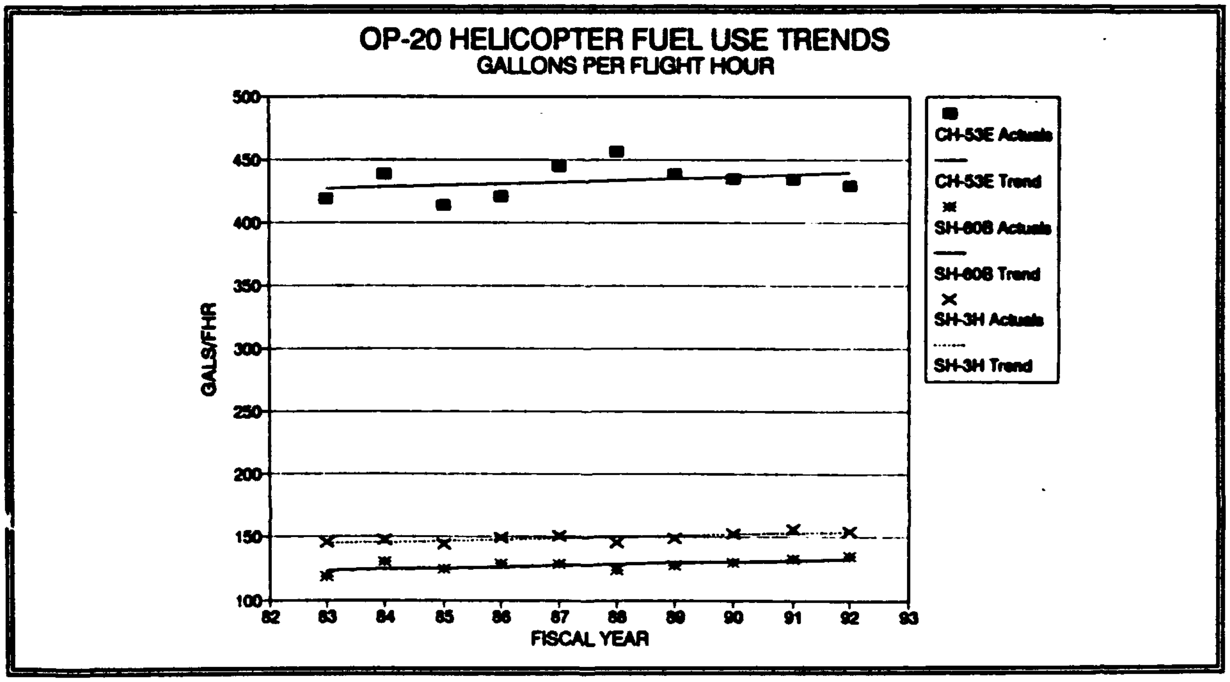
The Fighter/Attack chart best displays the basic underlying consistency in the POL usage data. The F/A-18 and A-6E trend lines are very similar and individual data points display a consistent variability around the trend line. The F-14 data also exhibits the same underlying trends except for consistent annual increases from FY89-FY92. The cyclic trend that is shared by all three aircraft is probably caused by minor variability in year end fuel consumption reporting practices that could be caused by purchasing POL from other services or other factors. The consistent underlying upward trend of about one-half percent per year is clear for the three fighter attack aircraft.



The Other Fixed Wing chart also displays an underlying consistency in the POL usage data. However, it is noteworthy that the S-3A, which has had no new aircraft entering the system since 1978, displays the most pronounced upwards trend. Its annual increase of 1.75% is far higher than that of any other aircraft examined. Since we can be certain that the S-3A operating fleet actually ages one year for each Fiscal Year, the population probably best displays the impact of aircraft age on POL consumption. In contrast, both the E-2C and P-3C, which did have significant quantities of new aircraft procured during the 1980's,along with major upgrade programs for the P-3C, exhibit significantly smaller rates of increase.

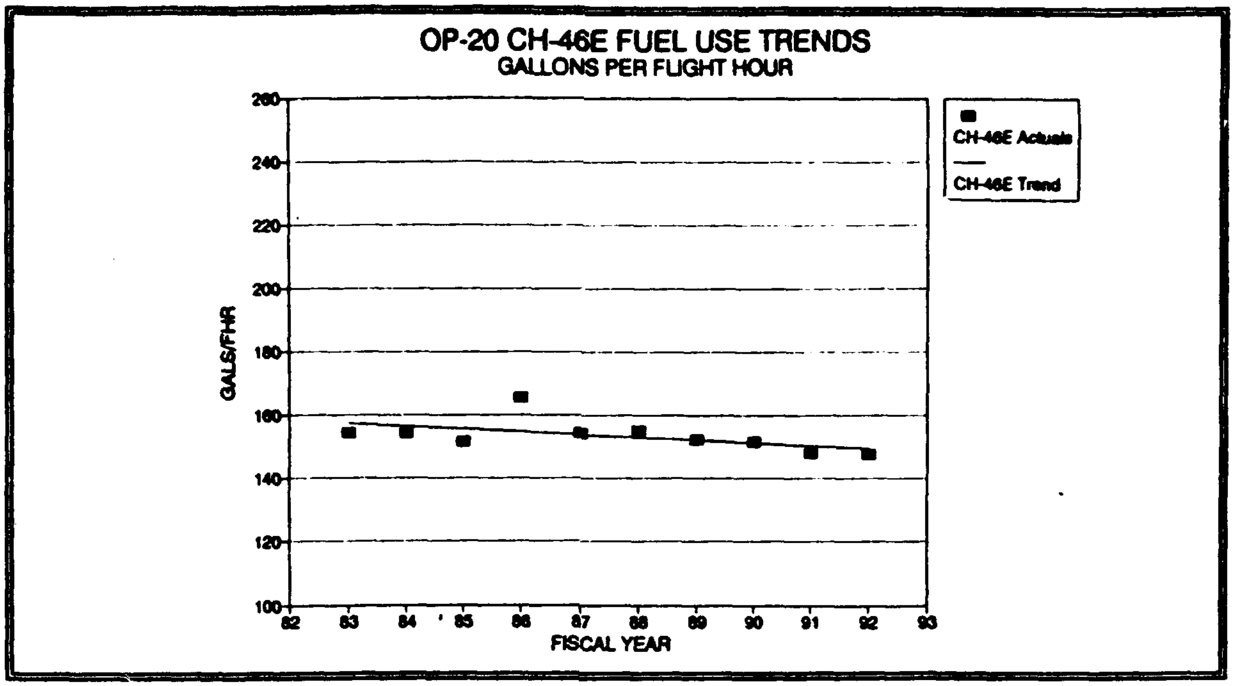


The Helicopter chart also displays some underlying consistency in the POL usage data. The SH-60B and SH-3H trend lines and underlying data are almost identical with an average annual increase of approximately .75%. In contrast the CH-53E has a much lower rate of increase caused by a downward trend from FY88 through FY92. This decreasing trend is almost totally caused by a Atlantic Fleet decreasing trend during those years. No reasons for this decrease have been identified.



The only aircraft in this study to exhibit a decreasing POL usage trend is the CH-46E. The CH-46E went through a complete Safety, Reliability & Maintainability (SR&M) program from 1985-88

where the entire airframe was reworked and refitted. This SR&M program effort appears to have significantly improved the fuel usage of the aircraft.



As a second step in the analysis Atlantic and Pacific fleet fuel consumption rates were also examined during the period FY83-FY92 in order to identify any trends that might be correlated with theater of operations. Similar directional trends are evident with nine aircraft showing increasing consumption trends and the CH-46E showing a decreasing trend for both fleet claimants. Two distinct differences between the fleets' POL usage patterns were observed. There were noticeable differences between the two fleets in the trend lines percent of change per year and in the gallons per flight hour consumed by individual T/M/S. The Atlantic Fleet reported significantly higher average gallons used per flight hour rates for the ten year period for all but the fixed wing Anti-Submarine Warfare and the E-2C aircraft. In addition, the Atlantic Fleet experienced higher rates of annual increases for all nine aircraft with increasing trend rates, and a concomitant lower rate of decrease for the CH-46E. These results would appear to indicate that theater of operations does have a significant impact on fuel use requirements. Spreadsheets containing the fleet data sets and charts displaying the resulting trends are contained in Appendix E, Enclosure 3.

FLEET FUEL USAGE COMPARISON TABLE

T/M/S	Atlantic Fleet Avg gal/hr	Atlantic Fleet Trend	Pacific Fleet Avg gal/hr	Pacific Fleet Trend
P-3C	720.2	0.70%	721.5	0.02%
S-3A	394.8	1.77%	408.7	1.51%
CH-53E	482.2	0.53%	387.5	0.33%
SH-60B	133.1	0.38%	126.3	0.31%
SH-3H	151.7	0.84%	146.0	0.29%
CH-46E	160.5	-0.25%	148.1	-1.20%
E-2C	367.0	0.89%	379.8	0.74%
A-6E	1,026.4	0.54%	1,012.7	0.50%
F-14A	1,206.5	1.03%	1,190.6	0.72%
F-18A	1,113.9	0.85%	1,075.1	0.08%

Recommendations for Future Estimating of POL Costs:

Extensive analyses of POL consumption rates for the ten T/M/S aircraft studied reveals that trends developed over a ten year period do show correlation of increasing POL usage with increasing aircraft age. Although fuel consumption rates vary from year to year, and are influenced by maintenance scheduling, airframe modifications, operational environment and operational tempo, the underlying pattern of increase is clear. Although the most recent year's POL usage data is probably the most valid predictor of future short term consumption rates any projections into the future should address the annual increases shown in the above tables. For the ten aircraft studied T/M/S specific rates from the POL AVERAGE ANNUAL CHANGE RATES FROM FY83-FY92 table represent the best predictor of future rates of increase. For T/M/S aircraft not specifically analyzed in this report an annual percentage increase of .60% would be most appropriate. However, fuel usage patterns should be continually monitored. As the impacts of age are emphasized by T/M/S aircraft not being replaced through new procurement it is likely that annual increases will approach the rate of the S-3A and be dramatically higher than those observed in this study.

END

"O" AND "I" LEVEL LABOR REQUIREMENTS

Description of "O" AND "I" Level labor requirements:

Direct labor hours at the Organizational ("O") and Intermediate ("I") levels of maintenance are most directly impacted by the condition of aircraft. Scheduled labor hours are used for pre-flight checks, periodic inspections and related efforts required to ensure that the aircraft is safely flyable. Unscheduled maintenance hours are required to fix systems and subsystems in the aircraft that have "gripes" caused by failures or indications of failure. Under Navy three level maintenance procedures the following types of efforts, reported under the VIDS/MAF system, are peculiar to the first two maintenance levels.

a. "O" maintenance is defined as maintenance performed by an operating unit to keep assigned aircraft in a full mission capable status. This includes the unscheduled removal and replacement of components using "O" level test equipment and hand tools. It also includes scheduled maintenance such as aircraft daily, preflight, postflight, conditional, calendar, and phase inspections all of which are considered preventive in nature.

b. "I" level maintenance is defined as maintenance performed in support of using organizations and consists of on and off equipment material support such as: scheduled and unscheduled maintenance of removed components and related support equipment; "O" level calibration requirements; and technical assistance.

The Navy repairs aeronautical equipment and material at the lowest practical maintenance level and expenditure, protects weapons systems from corrosive elements through an active corrosion control program, and promotes a systematic planned maintenance program. "O" and "I" level labor hour data sets referenced in this study are taken directly from the Aviation 3M Maintenance Data Collection System (MDS).

Potential Impact of Aircraft Age on Operating and Support Costs:

Previous age studies conducted by Naval Aviation Maintenance Office personnel using NALDA data have demonstrated consistent age related trends affecting aircraft and their major systems and subsystems. As aircraft age increases, identified in procurement blocks segregated by service life age, the Mean Flight Hour Between Failure (MFHBF) indicators become progressively worse. At the same time direct maintenance man hours per flight hour (DMMH/FH) consistently increase. Data from these prior studies showed annual DMMH/FH increases ranging from a low of approximately 3.5% (E-2C) to a high of approximately 9.3% (CH-53E) as the platforms aged. The purpose of this study is to evaluate labor data that is not segregated by age to see if age related trends are still observable. Because most T/M/S aircraft have completed production the most recent years of labor data should reflect populations that are aging in a uniform manner. This study examines ten T/M/S and attempts to evaluate trends and key man hour per flight hour

indicators that appear to be correlated with aircraft population age.

Data Sources Used for Analysis of Age Impacts on "O" and "I" labor:

Historical "O" and "I" reported maintenance man hour data covering the period FY83-FY92 was collected for the following ten Aircraft: P-3C, S-3A, CH-53E, SH-60B, SH-3H, CH-46E, E-2C, A-6E, F-14A, and F/A-18A. The **NALDA** Equipment Condition Analysis (**ECA**) data base was used for this purpose because it contains both operational usage and maintenance data for all Navy and Marine aircraft beginning in 1974. **ECA** contains two different sets of operational usage flight data files: **RAW FLIGHT** Data (**RAW FLT**) and **FLIGHT SUMMARY** Data (**FLT SUM**). It also contains two maintenance category data bases: the Depot Maintenance Data Sub-System (**DMDS**) and Aviation 3M Maintenance Data Collection System (**MDS**). Data covering the most recent ten years was extracted from these data sets in order to provide a stable ten year historical data base starting from the fleet introduction of the F/A-18A, CH-53E, and SH-60B.

ECA "710" FLIGHT ACTIVITY, INVENTORY AND UTILIZATION REPORT:

The flight utilization report provides monthly totals of aircraft inventory and utilization activity levels in terms of flight hours, number of sorties, average number of aircraft reporting and hours in a readiness reporting status. The RAW FLT Data was extracted using the NALDA ECA Report "710" modified to reflect **T/M/S** aircraft selection and **Fiscal Year** instead of Calendar Year data. A sample of this report is contained in Appendix F, enclosure (1).

ECA "510" RANKING PROGRAM OUTPUT REPORT:

The maintenance data report isolates and identifies equipment problems defined in terms of maintenance man hours, subdivided into contributions at the organizational and intermediate levels of maintenance. In addition, it orders all two digit Work Unit Code (WUC) labor hour data from the greatest to the smallest user of maintenance hours. This raw maintenance data was extracted using NALDA ECA REPORT "510" modified to reflect **T/M/S** aircraft selection and **Fiscal Year** instead of Calendar Year data. A sample of this report is also contained in Appendix F, enclosure (2).

DATA EXTRACTION AND ANALYSIS STEPS USED FOR THIS REPORT:

The data sets described above, consisting of twenty separate reports covering flight hour and maintenance information for the ten year period for each T/M/S, were very voluminous. In order to conduct meaningful analysis of this data the following categories of information were extracted and placed into spreadsheets for each reporting year by T/M/S:

a. Total flight hours;
b. Total "O" and "I" labor hours;
c. "O" level inspection (WUC 3) and corrosion control (WUC 4) hours; and
d. Total "O" and "I" level hours for the top five hour usage WUCS for each T/M/S aircraft.

Using this spreadsheet information, which is provided in Appendix F enclosure (2), the following types of analyses were conducted:

a. For each T/M/S annual labor usage was normalized as average maintenance man hours per flight hour at the "O", "I" and combined "O&I" levels. Ten year trends were developed for each of these labor categories by comparing average flight hours to the Fiscal Years in which they occurred. Even though there was substantial scatter in the underlying data, clear upward trends were identified for all aircraft in the population. Linear regression generated trend lines were used to generate average annual rates of change for each T/M/S labor category. Charts developed from this data are contained in Appendix F, enclosure (3).

b. The next analysis step involved segregating the following labor categories: WUC 03 ("O" level Inspection); WUC 04 ("O" level Corrosion Control), other "O" level labor and "I" level labor. These data sets, again normalized to average man hours per flight hour, were used to construct stacked bar charts for each T/M/S wherein all years could be easily compared. The basic purpose of these charts was to examine trends associated with changes in scheduled maintenance requirements contrasted with unscheduled maintenance requirements. Copies of these charts are contained in Appendix F, enclosure (4).

c. As a final analysis step annual "O" and "I" labor hour data sets were segregated out for the five Work Unit Codes (WUCs) contributing most over the ten year period to maintenance man hour usage for each T/M/S. Hours required for these five most significant maintenance usage systems were compared to total maintenance hours to assist in the identification of the underlying cause of increasing man power usage. Stacked bar charts developed from this data are contained in Appendix F, enclosure (5).

Analysis Results Concerning Potential Impact of Aircraft Age on "O" AND "I" LEVEL LABOR REQUIREMENTS:

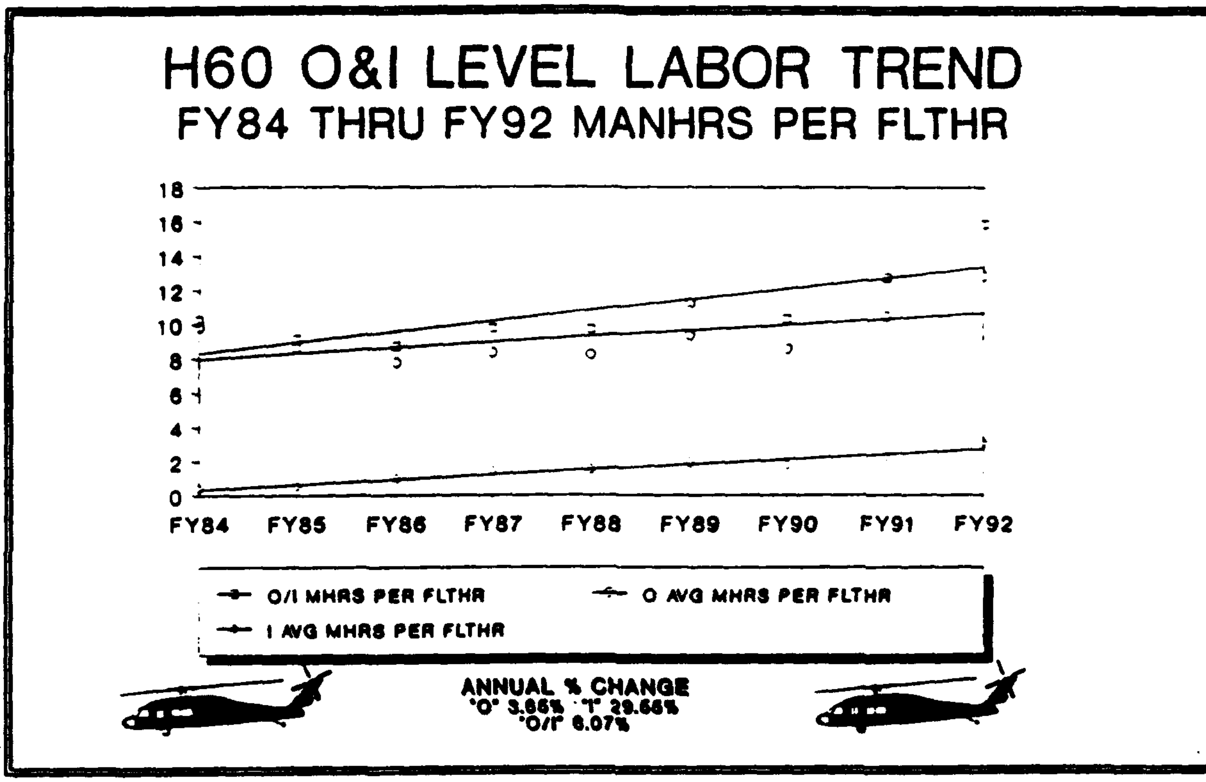
The ten T/M/S aircraft individually displayed increasing maintenance man hour requirement trends when the data sets from FY-83 thru FY-92 were examined. After discarding the FY83 data for the SH-60B, which consisted of two reporting aircraft flying only 823 hours, all T/M/S showed increasing trends as described in the table ANNUAL PERCENTAGE CHANGE RATES IN LABOR HOUR USAGE BY T/M/S below:

T/M/S	"O" Change	"I" Change	"O/I" Change
P-3C	4.26%	3.47%	4.01%
S-3A	4.35%	6.77%	5.16%
CH-53E	3.80%	17.13%	5.16%
SH-60B	3.65%	29.55%	6.07%
SH-3H	4.64%	-1.94%	3.31%
CH-46E	1.39%	4.77%	2.39%
E-2C	5.41%	2.56%	4.55%
A-6E	4.28%	0.97%	3.27%
F-14A	4.10%	1.44%	3.34%
F/A-18A	1.55%	12.78%	4.39%
10 A/C Avg	3.74%	7.75%	4.17%
F/W Avg	3.99%	4.67%	4.12%
Helo Avg	3.37%	12.38%	4.23%

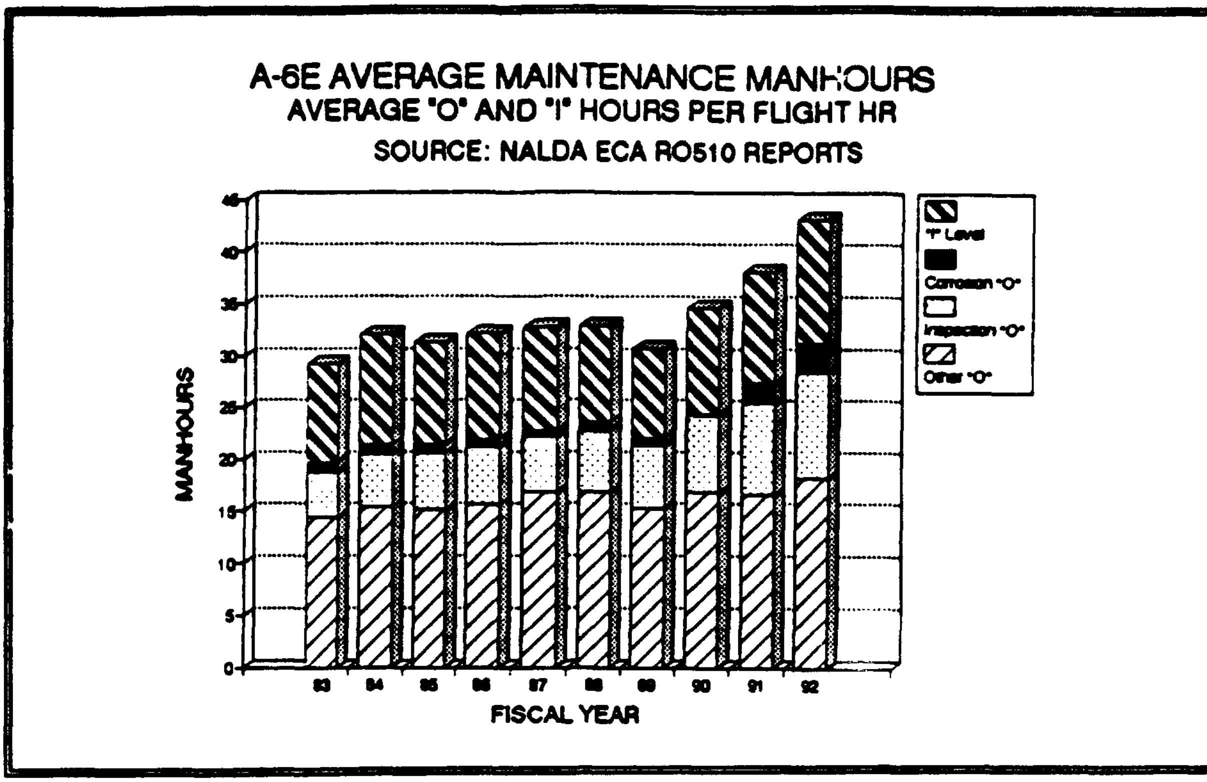
ANNUAL PERCENTAGE CHANGE RATES IN LABOR HOUR USAGE BY T/M/S

A cursory look at the above table would tend to indicate a surprising uniformity in the rates of increase over the ten year period. However, several very apparent anomalies can be readily observed. The "I" level rates of change demonstrate much wider variations than the "O" level change rates. These variations are probably caused by the fact that the most recently introduced fleet aircraft (SH-60B, CH-53E, and F/A-18A) all were under varying degrees of interim contractor support during the initial years after fleet introduction. "I" level maintenance requirements per flight hour were correspondingly low, but increased significantly as full organic support was realized. It can therefore be expected that "I" level rates of increase for those aircraft only will level off over time. A second interesting phenomena is that the oldest group of aircraft, the CH-46E, SH-3H, and the A-6E have the lowest average rates of increase while the newest T/M/S aircraft tend to have the highest rates. This apparent contradiction is probably caused by the fact that a new T/M/S aircraft MFHBF decreases most rapidly during the first years after introduction, as in shown in the NAMO age segregated data studies, but tends to level off over time to a lesser rate of decrease. A final interesting anomaly is that almost all of the T/M/S under review exhibited very significant increases in maintenance man hours per flight hour for the period FY89-FY92. In fact regression trends against the ten aircraft population for only those four years had R-squared values exceeding .97 with average rates of increase of over 12%. The SH-60B chart provided below, which is an example of the initial trend

line charts used to establish rates of increase clearly shows the increasing trend over the last three years and also the very significant changes in "I" level man hour requirements.



In order to better understand this phenomena all T/M/S were compared using charts that segregate WUC 03 ("O" level Inspection); WUC 04 ("O" level Corrosion Control), other "O" level labor, and "I" level labor. All ten aircraft experienced increases in average "unscheduled hours" per flight hour ranging from sixty percent to well over one hundred percent over the ten year period. Even more significantly, the percentage of total maintenance hours expended on scheduled maintenance increased significantly for all aircraft studied except for the F/A-18A and CH-53E, two of newest fleet aircraft. The SH-60B, the other new T/M/S, did not follow the same trend because of very significant increases in corrosion control effort during the last two reporting years. It is also noteworthy that dramatic increases occurred during the period FY91-FY92 for both inspection and corrosion control hours reported for all of the T/M/S studied except for the CH-53E and CH-46E. The next table, illustrating A-6E experience, is a good example of the trend.



Extensive discussions with fleet personnel stationed at NAMO led to the following tentative conclusions relating to these increases in scheduled maintenance hours:

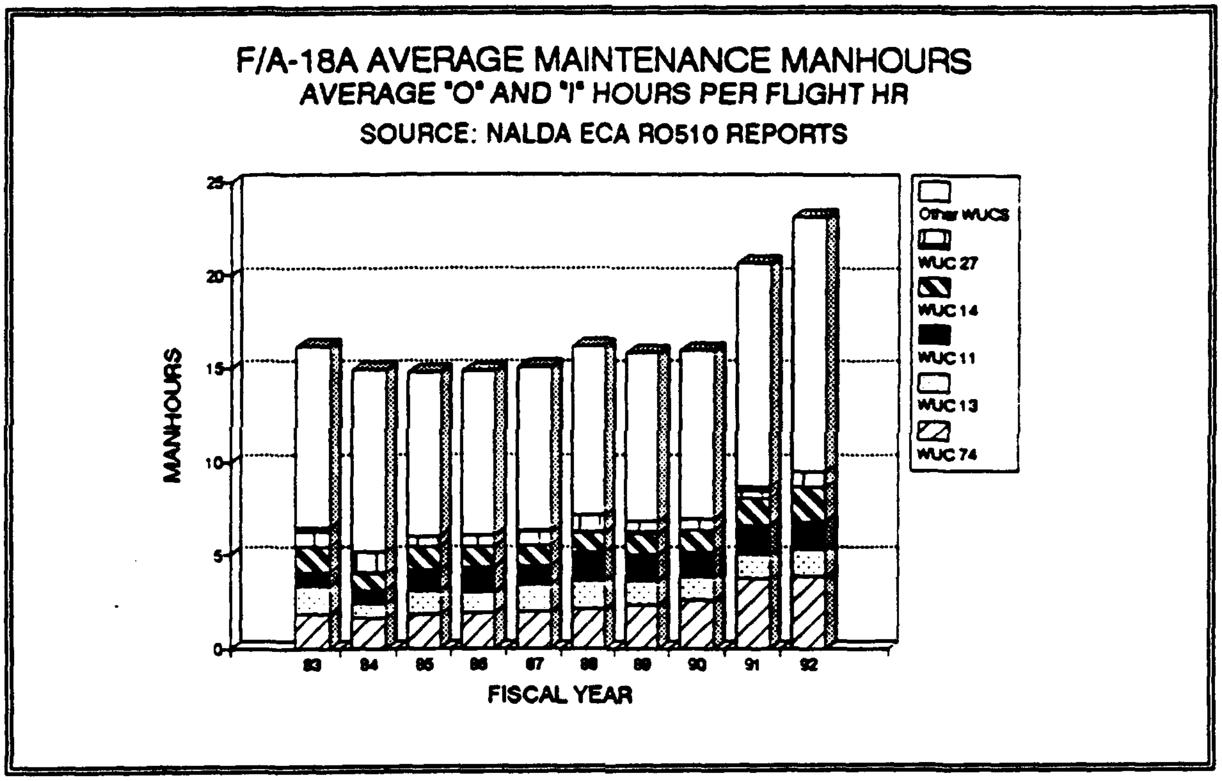
a. Changes were made to OPNAVINST 4790.2E in January 1989 which clarified certain labor hour reporting categories. Especially within the category of Subsystem Capability and Impact Reporting (SCIR) these changes may have led to more hours being documented.

b. Aircraft maintenance communities may also have reacted to reductions in squadron personnel manning associated with defense down sizing by more carefully documenting all legitimate hours. As an example, an individual who served as a P-3C squadron maintenance chief during this period, notes that specific direction was given to document all preflight inspection hours by the air crew. These hours had not always been fully reported in the past.

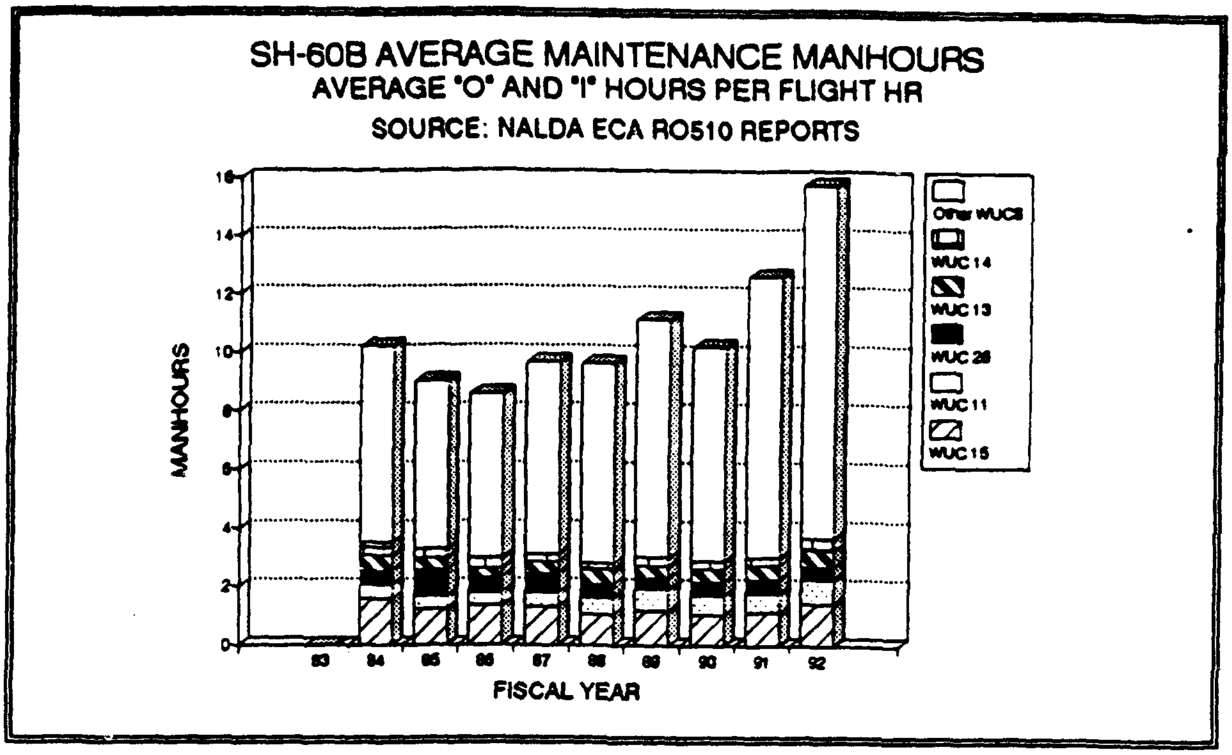
c. Another impact of downsizing that was frequently mentioned by fleet personnel involves loss of many of the most experienced individuals within each rating over the last several years which led to greater inefficiency both in conducting maintenance and performing inspections.

d. A final characteristic associated with older aircraft is that more communications requiring special inspections and corrosion control procedures occur on older aircraft. This obviously represents a significant age related component of change.

The maintenance man hour data was also analyzed to see if there were discernable trends in maintenance requirements for the "worst performing" systems of the aircraft during the ten year period. The five worst WUCs were identified for each T/M/S. As might be expected Airframes (WUC 11), Flight controls (WUC 14), Landing Gear (WUC 13), Bombing Navigation Systems (WUC 73), and Rotor Systems (WUC 15 for helicopters) predominated among the bad actors. Interestingly enough, all of the aircraft did experience generally upwards trends in average maintenance hours for the worst systems over the period being examined. As these WUCs represent systems that are most complex, or most abused during flight operations, it is very probable that these increases do signify an age related syndrome. The clearest example of a clearly increasing trend for the worst systems is shown in the F/A-18A below.



Finally, it is noteworthy that annual variations in total maintenance hours occur uniformly on all aircraft except the SH-60B which appears to be a special case. According to fleet maintenance personnel this particular aircraft was used particularly intensively, flying substantially more hours per year than initially planned after its introduction. While the "worst systems" have remained relatively stable other WUCS, including scheduled and corrosion related requirements, have dramatically increased. This probably is also a strong representation of age induced expedited "wearing out" of many of the SH-60B systems caused by accelerated usage. The SH-60B labor use profile is provided below to permit comparisons of man power usage trends.



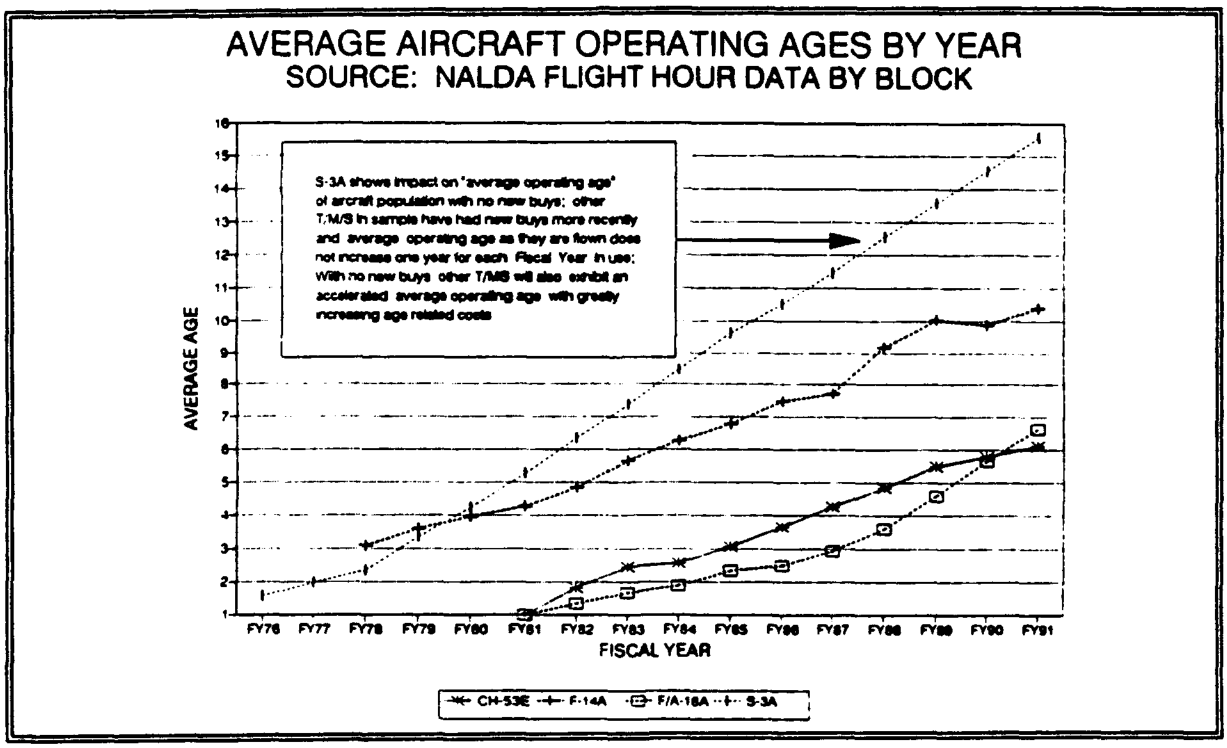
Recommendations for Future Estimating of Maintenance Manpower:

The current approach to estimating manpower costs for Navy aircraft Operations and Support estimates does not reflect changes in maintenance man hour usage caused by increased maintenance requirements. Instead it represents budget realities and pressures as reflected in the squadron manning authorizations and the Naval Aeronautical Organization reporting. In an era of downsizing these "budget reality" numbers have been decreasing. From the analysis of actual fleet maintenance history, however, it is clear that more work is continually being required from the maintenance community. Maintenance hour reporting extracted directly from NALDA for whole aircraft populations by Fiscal Year show maintenance manpower trends similar to those identified in the aircraft age studies previously referenced. This increased manpower effort is not free. Any cost projections going out more than several years must take into account that current squadron manning authorizations simply will not be able to complete all required work. Either manning will have to be increased or readiness and safety will decrease substantially. Our recommendation is that manpower cost annual percentage increases consistent with the table, **ANNUAL PERCENTAGE CHANGE RATES IN LABOR HOUR USAGE BY T/M/S**, be used for future projections. For those T/M/S not specifically covered in this study, fixed wing, helicopter, or ten aircraft population average increases as appropriate should be used. In addition, it is recommended that the recent dramatic increases in scheduled maintenance hours be carefully monitored to see if they represent a long term trend.

END

CONCLUSION

Study Results: This study demonstrates age related trends of increasing costs linked to aircraft service life "fleet age" for the five Operating and Support cost element categories under examination. These increasing cost trends are most visible when examining data sets most closely related to actual maintenance events. The clearest examples are found in the category of Aircraft Depot Overhaul/Support because depot rework actions can be directly linked to a particular airframe at a specific time in its chronological age. Because costs for the other categories studied cannot be directly associated with actual age, a presumed aging by fiscal year has been used in this study. The chart below supports this position by displaying average age of all aircraft operating by year against four sample T/M/S. The data was collected by aircraft tail number with individual aircraft age being determined from time of induction into the active inventory. As can be seen only the S-3A has a clear one-year annual increase in age for each fiscal year. The other three aircraft have lesser increases in "operational age" because of replacement aircraft entering the system through new procurement. With no new procurement aircraft planned to enter the system for most current T/M/S the increasing trends in the other O&S cost should amplified.



Further Study Recommendations: Increasing age related cost trends not only have implications for future budget requirements. They also should be considered for Cost and Operational

Effectiveness Analyses and all other studies requiring aircraft life cycle cost estimates. Because those data bases that closely reflect "flying hour program" annual funding do not always show increased costs of operations, costs trends should continue to be closely monitored using actual repair data. Other cost categories, including engine depot rework, which we are currently examining using detailed depot repair histories, should be studied and monitored to see if comparable trends exist. Decision makers should make age impacts a significant factor in their evaluations.